Final Report

The Effects of Individualized Actigraph Feedback and Coaching on Fatigue Management in Railroad Dispatchers

Karen E. Philbrick, Ph.D.
& Patrick Sherry, Ph.D.

University of Denver

This research was sponsored in part by Grants from the
National Center for Intermodal Transportation,
The Federal Railroad Administration,
and the
Burlington Northern Sante Fe Railroad

Table of Contents

Executive Summary ... 3
Introduction ... 4
History of Fatigue in the Transportation Industry ... 4
Role of Feedback in Safety Performance ... 5
Behavioral Approaches to Safety ... 5
Effects of Feedback ... 10
Coaching Model ... 12
Participant Information ... 13
Assessment Instruments ... 14
Additional Information Regarding Study Materials ... 15
Self-Report Survey Results ... 17
Time 1 Data ... 17
Results of Actigraph Comparisons ... 21
Discussion ... 22
References ... 24
References ... 24

Executive Summary

A total of thirty three dispatchers completed the three-month study designed to assess the functionality of improving individual sleep habits with Actigraph Performance Feedback. There were 5 people from first shift, 5 people from second shift, 13 people from third shift, and 10 people from the extra board. Participants wore the actigraphs for a total of 60 days. For the first 30 day period participants wore traditional non-performance feedback actigraphs. For the remaining days of the study participants wore performance feedback actigraphs. This was followed by and additional 30 days of wearing the traditional non-performance feedback actigraphs.

The key focus of the study was the pilot and development of fatigue management focused coaching based on the actigraph results and targeted towards key behavior changes. Each participant received feedback on the results of the actigraph baseline period and identified several areas for improvement over the next 30 day period. Participants wore the performance feedback actigraphs and were interviewed for their reactions.

Results indicate that study participants generally rated their experience with the performance feedback actigraph as a favorable one. In addition, a 10% improvement in amount of sleep obtained was observed. While this result is not statistically significant the results were in the expected direction and suggest the need for further investigation with this approach. Small sample sizes, problems with equipment availability, and lack of severity of sleep hygiene habits were noted as contributing to the overall effect.

As in previous studies respondents indicated that the performance readings made them more aware of their fatigue levels and made it increasingly likely that they would use appropriate fatigue management techniques to prepare themselves for work.

Introduction

History of Fatigue in the Transportation Industry

The study of the role of fatigue and transportation has a long history. As early as 1907, Congress enacted the Hours of Service Act to enhance railroad safety by limiting the number of hours that railroad engineers and other railroad employees could work. However, the earliest published study of the effects of fatigue on locomotive engineers was in 1971 (Grant, 1971). Due to the ever-changing complexity of the demands faced by drivers and operators in all modes of transportation, the topic of fatigue continues to be the focus of intense study (Sherry, Bart, & Atwater, 1997).

Over the past few years there have been increased efforts to address the problems of fatigue in the railroad industry. A USDOT/FRA report in 1991 (Pollard, 1991) identified causes of fatigue, such as: uncertainty about the time of one's next assignment, excessive working hours, long commutes and waiting times before beginning work, unsatisfactory conditions for sleeping at some terminals, and the decision not to rest during the day even when subject to call the next night. Suggestions for remedying the situation included: a minimum of eight hours notice before being called to work, greater predictability in scheduling trains, and division of assignments according to blocks of time. However, it is important to realize that at this point *while much is known, much is not known* about fatigue in the transportation industry.

Measuring fatigue in the workplace is a complex process. It is common to use both subjective and objective measures of fatigue and alertness to evaluate the impact of a countermeasure, as multiple measures allow the investigator to triangulate the truth and produce a more convincing conclusion. There are four kinds of measures that are typically used in measuring fatigue; physiological, behavioral, subjective self-report and performance measures.

Behavioral measures of sleep have been gaining popularity in the last few years. These devices, most commonly known as actigraphs, have been used to measure sleep based on the frequency of body movement. The test subject wears a wristwatch-like recording device that detects wrist movements. The number of body movements recorded during a specified time period, or epoch, has been significantly correlated with the presence of sleep. Several studies have been conducted using actigraphy that have found a significant relationship between EEG levels and the presence of sleep as indicated by actigraph measures. Actigraphy has been used to determine the amount of sleep that a person is obtaining and these measures are useful for studies that cannot be conducted under controlled settings. Actigraphy measurements, and sleep wake algorithms, have been validated by demonstrating significant correlations with data obtained from polysomnographic measures ($r = .90$) (Cole, et al, 1992). Thus, it appears that the use of actigraphy may be as useful and valid as other more expensive and time-consuming options.

Role of Feedback in Safety Performance

Behavioral Approaches to Safety

Behaviorism began in the early 1900s as an attempt to understand the human learning process and was largely promoted by a psychologist named Watson (1930). It was later, in the 20th century, that B.F. Skinner wrote a book called *Walden Two (1948)* in which he outlined a utopian society based on the application of behavioral principles. This led to the modern study of behavior modification.

The application of behavioral psychology to industrial and business settings was popularized in the late 70's and early 80's. Petersen began writing about the behavioral influences on the occurrence of accidents and injuries in the workplace (Petersen, 1984). He described the role of specific acts or tasks that occur in the process of completing or performing ones prescribed duties. A typical example is the act of placing one's hand in the way of a press or a blade to remove an obstruction and in the process suffering a cut or other injury. Similarly, the act of using a seat belt is considered a safe act that reduces the risk of serious injury following a collision. These and other acts or procedures engaged in while carrying out job duties are considered behavioral influences on the occurrences of accidents or injuries.

A complete understanding of the factors that influence the occurrence of safe work behavior, however, must be seen in the context of the interaction of the person and the environment. It is typically accepted that the behavior of a specific individual is related to the situation that they find themselves in. In the late 1940's Kurt Lewin and his colleagues at the University of Iowa began to theorize on the effects of the interaction of these variables. Lewin proposed the notion that the interaction of the person with the environment would specifically influence the occurrence of behavior. These ideas then led to the development of the now famous formula:

$$\mathbf{B} = f\,(\mathbf{P} * \mathbf{E})$$

Where B equals behavior, P is a person or person variable, and E is the environment or an environmental variable. Thus the formula indicates that behavior is a function of the interaction of the person and the environment.

If we look at behavior in this context then we will see that we are interested in the effects of other variables on the performance of a specific behavior. Accordingly, we are concerned with the occurrence of desired safe work behaviors and therefore in the subset of performance indicators which will be related to the acceptance and engagement in critical work behavior.

Over the past 30 years a number of models have been proposed to understand unsafe work performance or in common terms unsafe acts. For example, in 1911 Greenwood and Woods, as part of the Industrial Research Board in Australia, statistically examined accident rates in a munitions factory. Analysis of the data suggested that some people were consistently more involved in accidents than others, thereby supporting the proposition that "accident proneness" existed. This became a model for explaining and understanding safety thinking and research for almost 50 years (Cooper, 1998).

Heinrich (1931) however, proposed that accidents were caused either by an unsafe act, an unsafe condition, or both. His theory was termed Heinrich's *Domino Model of Accident Causation* and it brought in to play the idea that safe behavior was important as well as the roles that behavior, conditions, or the situation played. Essentially, the Domino model postulated that accidents were caused by a sequence of events, which covered five distinct phases. The first phase was considered the hereditary and environment of the person which would predispose them to act in a certain way. Heinrich argued that each of these was like a series of dominos arranged in such a way that if one fell then the others were likely to fall in sequence. Heinrich concluded that the key domino was that pertaining to unsafe acts and the notion that 80% of accidents were triggered by unsafe acts, with the remaining 20% being triggered by unsafe conditions.

Figure 1. Domino Theory of Safety Performance

Weaver (1971) modified the original theory to propose that the last three dominos in the sequence were caused by management omissions. Weaver believed that the underlying cause of accidents were unsafe acts. However, he believed that the cause could be determined by asking, "What was the unsafe act? Why was it allowed to occur? " and "Were rules and procedures known to all concerned?". In essence, this model placed considerable responsibility for performance of accidents onto the shoulders of management and supervision, while also recognizing the importance of the system, which contributed to the conditions, which produced performance.

In 1976, Adams suggested that organizational, rather than person-centered factors, were related to the occurrence of accidents. In effect, he moved away from the "accident proneness" model and into a more complete culture and situation-centered focus. Adams suggested that unsafe work performance was due to the management structure; organization objectives; the organization of the work, and how work tasks were planned and executed. Thus, according to Cooper (1998), Adams was one of the first theorists to specifically highlight the multiple interactions between organizational structure, systems and sub-systems, and unsafe conditions and/or employee's safety work performance.

It was not until Reason (1990) argued that all organizations carried the seeds of their own demise, that theorists began looking at the organizational structure to understand the roots of unsafe behavior. He suggested that a system carried its own latent failures in the form of managerial factors and individual factors. Reason identified various types of accident performance factors and argued for the focus on the overall management system, particularly in relation to the implementation of the organization's strategic decisions.

Haynes, Pine, & Fitch (1982) evaluated the effectiveness of an intervention package (feedback, competition, and incentives) in reducing the accident rate of urban transit operators. One hundred operators were divided into teams and offered rewards for accident-free driving over 18 weeks. Results showed a 24.9% reduction in accident rates, establishing a definite link between the intervention and reduction in accident rates, severity, and cost.

Karan and Kopelman (1987) provided outcome feedback regarding the actual frequency of accidents at a vehicle dispatch and maintenance facility. This outcome feedback was not provided at two similar comparison facilities. Over a 43-week experimental period, the rate of vehicular accidents declined by roughly 5% in the experimental facility, while accidents increased by roughly 17% in the two comparison facilities—thus, there was an overall improvement of approximately 22%. Concurrently, the rate of industrial accidents declined by roughly 12% in the experimental facility versus an increase of 4% in the comparison facilities--an overall improvement of approximately 16%.

There are numerous examples of the application of this type of model to the occupational safety arena. Two studies by Sulzer-Azaroff (1981, 1997) demonstrated the application of these principles to an industrial laboratory setting and a nursing home. Both situations met with considerable behavioral change. Additionally, a study by Sierro, Boon, Kok, and Sierro (1989) was designed to change the driving behavior of mail-van drivers so as to encourage energy saving. Based on empirical analysis, three approaches were used to influence driving behavior: providing information, providing task assignment and control, and providing feedback on gasoline consumption. The effectiveness of the program was tested in a field experiment. Attitudes, social norms, and reported behavior changed, and energy savings of more than 7% were achieved, compared with a control group.

More recently, Cooper (1998) offered a model of safe work behavior that identified a reciprocal relationship between an organization's safety management systems, the prevailing safety climate, and the daily goal-directed safety behavior. Cooper argued that each of these components could be directly measured and quantified. From a practical standpoint, the model can be applied to each component variable. For example, Cooper suggested measuring people's attitudes (Person) about the prevailing climate (Situation), the level of perceived risk (Person), and management's commitment to safety (Situation). According to the model, the ability to implement new safety behavior is affected by the levels of commitment, competing goals, and quality of organizational communication.

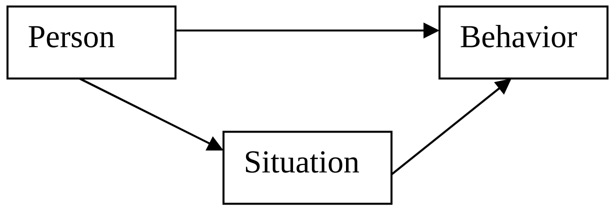


Figure 2. Behavioral Based Safety Performance Model.

A similar model of factors that affect safe work performance was suggested by Geller (1998). This model included the Person, Environment, and Behavior variables in a model labeled the Safety Triad (Geller, 1989). In this model, the three factors are thought to be dynamic and interactive, such that changes in one factor eventually impact the other two. For example, behaviors that reduce the probability of injury often involve environmental change and lead to attitudes consistent with safe work performance. According to Geller, the behavior based approach starts by identifying observable behaviors targeted for change and the environmental conditions and contingencies that can be manipulated to influence the target behaviors in desired directions.

A second type of behavioral influence on occupational safety is the role of antecedent factors such as psychological or attitudinal influences. Most traditional safety programs emphasize a need to increase employee's awareness of safety hazards and in so doing prevent injury. This is considered an environmental influence on behavior. The influences on behavior may change worker activities such that unsafe acts occur. Other research however, has shown that job satisfaction, stress (Weller & Sherry, 1992), and attitudes toward supervisors (Sherry, 1991) are significantly related to the occurrence of accidents, health, and job safety.

As can be seen from the figure below, Sherry (1992) argued that the effects of person and organizational behavior on the behaviors that lead to safe work performance are significant. However, there are several other factors that in turn influence behavior. Behavior is influenced by the effects of antecedents, consequences, and actions that precede a specific behavior and is paramount to understanding and eventually controlling the behavior that is deemed to be risky or even unsafe. Again, Sherry (1992), using a behavioral approach to safety, attempted to identify the antecedents, behaviors desired, and the consequences of those behaviors. This ABC approach to understanding work performance was useful in changing the behavior of the employees of a railroad car repair facility.

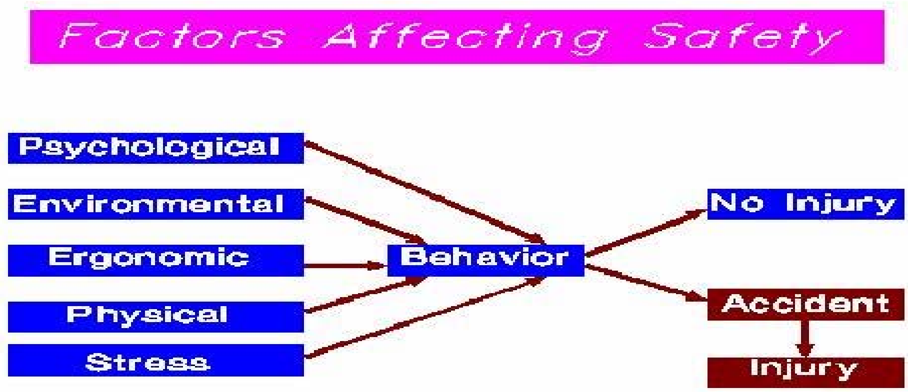


Figure 2. Factors Affecting Safety

Writing about the need to improve the environmental conditions under which behavior change might be maintained, Krause, Hidley and Hodson (1990) promoted the idea that a safety corporate environment needed to be created so as to sustain the behaviors that needed to be changed.

Krause, Hidley and Hodson (1990) applied behavioral principles to improve safety performance by engaging workers in the improvement process, teaching them to identify critical safety behaviors, perform observations to gather data, provide feedback to encourage improvement, and use gathered data to target system factors for positive change. This approach combines the principles of applied behavior analysis (and "behavior modification"), quality management, organization development, and risk management. This approach attempts to put at its crux the need to focus on behaviors, actual human activities performed in the workplace, as opposed to focusing on accidents and incidents rates.

One transportation application of behavioral approaches to safety cited in Knipling and Olsgard (2000) involved a North American oil and gas company. Drivers identified a cluster of 16 behaviors common to their history of vehicle-related accidents and injuries. These 16 behaviors fell into two categories: preventive maintenance (e.g., inspecting brakes) and driving behaviors (e.g., following distance, checking mirrors, avoiding distractions). Once these behaviors were identified and operationally defined, observations were initiated to collect data, provide feedback, and encourage improvement. Both self-observation and peer-to-peer observation was encouraged. Management monitored progress but the emphasis was not on surveillance or punishment for recalcitrant drivers.

Geller (1998) too, writes about an antecedent, behavior, consequent process in which it is imperative to define a critical target behavior. This critical behavior is then observed during a pre-intervention baseline period to set behavior change goals and also to understand the natural environmental or social factors influencing the target behaviors. Next, there is an intervention designed to change the target behaviors in the desired direction. Finally, a test to determine the impact of the intervention procedure by continuing to observe and record the target behaviors during the intervention program was developed.

Geller (2000) evaluated *behavior*-based interventions (BBIs) designed to increase the safe-driving practices of nineteen 44 year-old pizza deliverers. He focused on goal-setting and feedback techniques, including: (a) non-numerical goals in an awareness and promise card intervention; (b) non-numerical goals mandated as company policy; (c) participative and assigned group goal setting and feedback; (d) group goal setting and feedback with added public individualized feedback; (e) individualized feedback and competition; and (f) private individualized feedback paired with dynamic, static, or dynamic and static goals.

An additional BBI evaluated a community program in which pizza deliverers acted as *behavior change* (BC) agents for *safety*-belt use. Two BBI effectiveness models were evaluated for their ability to help practitioners design BBIs that maximize both short-term and long-term impacts as well as desirable response generalization. The amounts of individual involvement, peer support, response information, and external consequences influenced the beneficial impacts of the BBIs. Additionally, behavior change and maintenance after BBI withdrawal varied with the degree of peer support and involvement in the BBIs' designs. Employee involvement increased desirable response generalization while external consequences seemed to be associated with undesirable spread of presumed counter control effects.

This review then, has identified the behavioral based safety approach as one that may be useful in addressing the concerns that operators have regarding the adoption and utilization of various OBSM systems. Perhaps, through the use of behaviorally based safety concepts, the resistance and reluctance to engage in safe work behaviors that involve the utilization of OBSM systems can be reduced.

Effects of Feedback

Much of the success of the behavioral approach to safety is based on the notion that feedback of any type can have a positive effect on safety behavior. The basic idea comes from operant theory (Skinner, 1947) as well as cognitive – behavioral theories on behavior change (Beck, 1993). However, the effects of feedback on performance have only received attention in the psychological research literature.

A review article by Balzer (1989) found that in some conditions feedback interventions improve performance, in other conditions feedback interventions have no apparent effect on performance, and in yet others feedback interventions debilitate performance. These conditions or moderators of the effect of feedback interventions (FIs) on performance are poorly understood and go far beyond the view that feedback interventions improve performance unless the feedback is too negative. However, many researchers still assume that feedback interventions consistently improve performance.

Two meta-analyses, testing theories that contained feedback as a component, found only a weak contribution of feedback to performance. First, Harris and Rosenthal (1985) tested several hypotheses designed to explain the well-documented beneficial effect of expectations of others (agents) on one's performance. When agents (primarily teachers) expect high performance from others (primarily students), they may provide more feedback, more challenging goals, and create a better climate for the students. This meta-analysis showed that the amount of feedback provided by the agent had only a meager effect on performance (r = .07), whereas other variables, such as the climate that the agent created for the other person had strong effects on performance, (r = .36) (Harris & Rosenthal, 1985). Second, a test of the job-characteristics model showed that perceived knowledge of results had a weak relationship with performance (r = .09) but a stronger effect on variables such as overall job satisfaction (r = .41; Fried & Ferris, 1987). The meta-analysis showed, not surprisingly, that FIs improve performance by approximately .4 of a standard deviation (a finding similar to a limited meta-analysis of FIs by Guzzo, Jette, & Katzell, 1985). However, there was also a great variability in FI effects such that in over one third of the cases FIs reduced performance. Most of the observed variability cannot be explained by sampling or other errors. As such, it provides strong empirical support for the conclusion of FI researchers who are identified with various theoretical approaches: namely, FIs are double-edged swords because FIs do not always increase performance and under certain conditions are detrimental to performance.

FI cues that seem to direct attention to task-motivation or task-learning processes may augment FI effects on performance. This pattern of findings provides reasonable support for the first two propositions. Specifically, both praise and FI designed to discourage were postulated to increase attention to meta-task processes and were found to attenuate FI effects. Furthermore, both the attenuating effect of praise and the non-significant effect of an FI are not easily predicted by most FI-related theories. The debilitating effects of praise on performance received some direct experimental support both in the laboratory and in the field and were explained, respectively, by a model of self-attention (Baumeister et al., 1990) and by control theory (Waldersee & Luthans, 1994).

Physical tasks and following rules tasks yielded weaker FI effects, and memory tasks yielded stronger FI effects. Other results strongly suggest that task type places a serious boundary condition on the knowledge and effectiveness of various interventions designed to improve performance (cf. Hammond, 1992). Therefore, some researchers suggest that the lack of a valid task taxonomy that can be used across vastly different tasks (e.g., vigilance, memory, and adherence to regulations) poses a serious obstacle for FI research. Moreover, even within similar types of tasks the "effects of feedback seem to be very sensitive to the task environment [difficulty]" (Castellan & Swaine, 1977, p. 118).

The effects of individual differences on the effects of FI have also recently been examined. In a laboratory study using college students Nease (1999) found that individuals with high self-efficacy are less accepting of consistently negative feedback than are low-self-efficacy individuals, who do not appear to differ in their acceptance of repeated negative feedback.

Nease (1999) argued that these results were consistent with previous research on self-verification theory which posits that people tend to endorse feedback about themselves as valid only when that feedback fits within their conceptions of self (Markus, 1977 ; Swann, 1987). Moreover, studies supporting this theory have also found that people tend to attribute self-confirmatory feedback to personal characteristics, whereas feedback that is disconfirmatory is attributed to the source of the feedback (Swann, Griffin, Predmore, & Gaines, 1987). Other research has found that individuals with low levels of self-esteem are willing to accept more responsibility for negative feedback and are more likely to perceive that feedback as accurate compared with high-self-esteem individuals (Jussim, Yen, & Aiello, 1995).

These results suggest the need to further investigate the overall characteristics of the task and the cues associated with the task to be performed. As yet, it cannot be said with any certainty that feedback alone will increase performance. Individuals may choose to ignore feedback for many reasons including task characteristics and personality variables. Further research is needed to clarify these phenomena.

Thus, research studies suggest that it is a combination of factors that work together to affect performance. To understand which factors have the ability to alter behavior, further study of performance feedback is needed to understand the effects that this type of feedback may have on an individual's behavior.

Description of the Project and Data Collection Procedures

The current project was designed to obtain individual participation in the monitoring of fatigue through the use of individual fatigue monitors. The goal of this study was to determine whether individual feedback devices, such as actigraphs, could be useful for helping railroad employee's better plan their sleep and wake activity. Project participation consisted of the completion of a consent-form, several survey questionnaires, a daily sleep log, and wearing an Actigraph, which measured sleep and work during the course of the project.

Prior to soliciting participation, it was necessary to identify those conditions that would exclude an engineer from participation. Specifically, those persons who were not able to wear the activity monitors for the full period were not eligible to participate. Similarly, persons who had a diagnosed condition that affected their sleep patterns, and persons who were working a schedule that would be dramatically different from the typical pool assignment also were not eligible for participation.

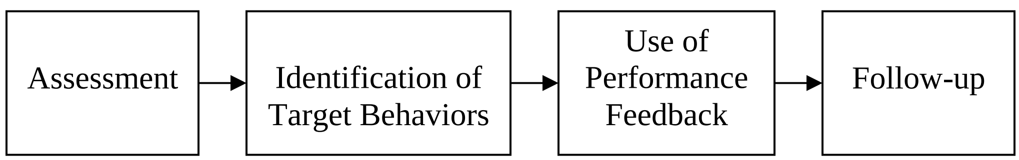
Once an individual agreed to participate, he or she was notified that data collected as a result of participation in the project would only be shared with the participants themselves. They were also notified that the BNSF agreed not to request or seek to obtain data collected as a result of this project. Finally, participants were informed that only summary statistics such as means and percentages, not individual scores or results, would be revealed to the BNSF or any other group or entity in the course of discussing the results of the project. Each person was assured that participation was voluntary and could be discontinued at any time.

Coaching Model

In order to intervene effectively with the persons wearing the sleep watch actigraphs it was decided that it would be necessary to develop a more effective instructional and coaching intervention. The rationale for this was the fact that for the most part we are asking individuals to change their behavior. This means that people will need some help in changing their behavior. In addition, the information on sleep and behavior is not common knowledge, consequently there is a learning curve that must be traveled in order to be able to utilize the information.

The attached model outlines the steps that were used in order to be able to address the need to change behavior. First, the person will be assessed for the extent of any fatigue related problems. This will be accomplished through the use of the actigraph data. Next, the individual will be asked to identify the areas of sleep hygiene and behavior that they would like to alter or improve. These will be identified by the research assistant and the individual. Finally, the individual will be asked to indicate the extent to which they would be likely to engage in the activities identified and asked to identify the proposed change.

Coaching Model



Participant Information

In order to begin the project and to recruit the necessary participants, it was necessary to spend a significant period of time at the location. The goal of this project was to recruit thirty engineers who would commit to wearing an Actigraph sleep watch, 24 hours a day, for two consecutive thirty day periods. In addition to wearing the sleep watch, participants were asked to complete a daily sleep log that cataloged their activities for each of the thirty days periods that they were wearing the watches. This was a simple task, whereby a participant would account for their actions according to a legend (e.g., “s” = sleep/ “w” = work/ etc.). Additionally, all participants were asked to complete a survey designed to identify fatigue related issues.

To recruit the actigraph participants, each potential participant received an explanation of the project and the use of the actigraph from one of the research assistants during a break during the workday. Participants were informed of the purpose of the study and invited to participate by 1) completing a survey, 2) wearing an actigraph sleep watch, and 3) completing a daily sleep log.

A total of 33 individuals agreed to complete all three portions of the study. Below is an illustrative breakdown of these participants by shift assignment.

Shift worked

		Frequency	Percent
Valid	First	8	22.9
	Second	5	14.3
	Third	12	34.3
	Variable	7	20.0
	Extra	3	8.6
	Total	35	100.0

Characteristic	**N**
Gender	
Male	31
Female	4

Although 35 dispatchers agreed to participate in the study there was one person (male) who dropped out.

During the first month of the study all participants wore the same type of non-performance actigraph. This was done for a variety of reasons. First and foremost, it allowed the researchers to gather baseline activity data on each participant, and it also allowed each participant a period of time to become accustomed to keeping a daily sleep log and to wearing a large "wristwatch" for approximately 24 hours a day. After the first thirty-day period ended participants received the performance watches and wore them for a total of 30 days. Finally, participants also wore the actigraphs for a third 30 period.

The other main intervention with this particular study was the inclusion of a "coaching" session that prepared participants to deal more effectively with the feedback received from the performance actigraphs. This coaching session was held after the first 30 day baseline period and consisted of an explanation of the actigraph results for each actigraph wearer. The sessions were conducted by trained research assistants who were able to provide detailed explanations of the output as well as work with the participants to identify additional behavioral changes as a result of the information received. The focus of the intervention had a second main purpose which was to identify sleep hygiene habits that the study participant felt might need to be changed to enhance their overall

Assessment Instruments

The assessment instruments that were administered at each phase consisted of the following:

Table 1. Assessment Instruments.

Phase I – Baseline – 30 days

1. Fatigue Survey
• Stanford Sleepiness Scale
• Eppworth Sleepiness Scale
• Denver Job Satisfaction Scale
• Denver Fatigue Adjective Checklist
• Denver Sleepiness Scale
• Denver Depression Scale
• Denver Anxiety Scale
• Denver Stress Scale
• Denver Quality of Life Scale
• Shift Work Index – Exhaustion
• Shift Work Index – Depression
• Shift Work Index - Quality of Life
2. Actigraph Monitoring
3. Sleep and Activity Logs
Phase II – Wearing of Performance Feedback Actigraphs – 30 days
1. Fatigue Survey (please see above for included indices)
2. Actigraph Monitoring
3. Sleep and Activity Logs
Phase III – Post testing

Additional Information Regarding Study Materials

Actigraphs -- These devices are essentially motion detectors. They are able to keep track of the amount of body movement that occurs. They are mechanical and do not harm the individual wearing them. They do not keep track of pulse or electrical activity. They must be worn continuously but should be taken off for showering or bathing or vigorous exercise. Various studies over the years have demonstrated a very strong relationship between body movement and sleep.

Here is what an Actigraph looks like….

Figure 3. Actigraph.

Participants were asked to wear the device for 30 days. At the end of the thirty-day period they were given feedback on their work/rest habits during the monitoring period and then were asked to wear the device for another thirty days.

Each study participant was shown his or her Actigraph feedback chart and a discussion of the information contained in the report took place. Such feedback charts look like the one listed below and basically describe the work/rest sleep/wake pattern that the individual engaged in during the 30-day monitoring period. The chart below shows the sleep/wake activity for a person for approximately seven days. The dark black lines show the activity. The turquoise shaded areas show the likely sleep episodes.

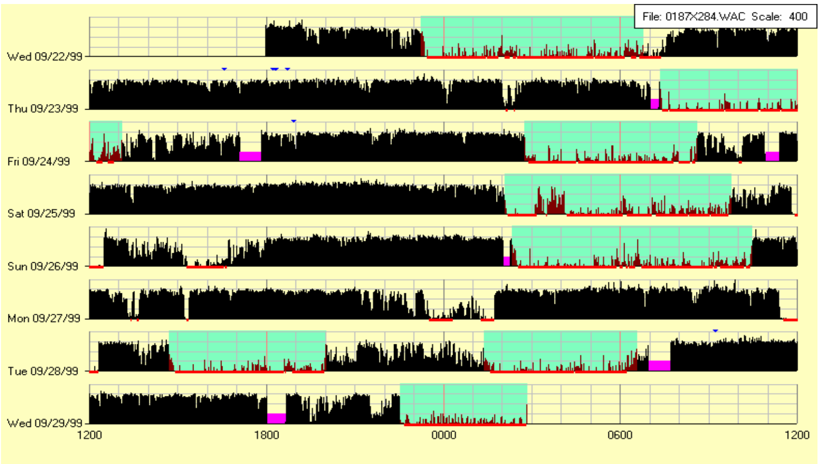


Figure 4. Actigraph Output

Researchers were on-site to address any questions and/or concerns that participants had to the information they were given regarding their work/rest habits. Such information included mean activity score, sleep after wake onset, sleep efficiency, wake episodes, and activity indices.

Self-Report Survey Results

There are several ways to determine whether a person is fatigued or not. We can simply ask the person if they are fatigued or sleepy or tired. We can examine their brain waves, we can examine their performance, or we can see how long it takes them to fall asleep. All of these approaches have pros and cons. In field settings, like the railroad, it is most economical to ask participants to complete standardized questionnaires that have been correlated with laboratory findings. This technique is typically used to make preliminary assessments of persons who are presenting with possible sleep disorders in medical settings. These questionnaires then give a reasonable indication of the level of fatigue and tiredness that persons are experiencing.

Time 1 Data

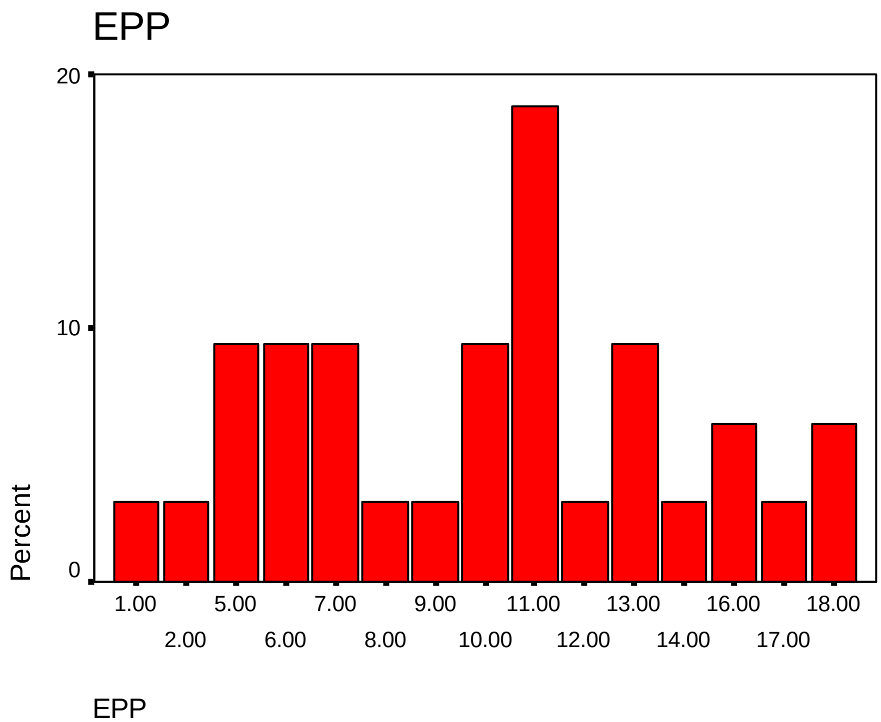
No significant differences in between first and second shift were noted at pre-testing thereby warranting collapsing of first and second shift data for analysis. As can be seen from these analyses there was little difference between the scores of the shifts on the variables in question.

Results indicate that 18.7 percent of respondents to the Epworth Sleepiness scale scored on in the clinical range. In addition, only 6.3% of respondents indicated that they strongly agreed with the statement that they came to rest fully rested and alert.

Eppworth Scale Distribution

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	1	3.1	3.1	3.1
	2.00	1	3.1	3.1	6.3
	5.00	3	9.4	9.4	15.6
	6.00	3	9.4	9.4	25.0
	7.00	3	9.4	9.4	34.4
	8.00	1	3.1	3.1	37.5
	9.00	1	3.1	3.1	40.6
	10.00	3	9.4	9.4	50.0
	11.00	6	18.8	18.8	68.8
	12.00	1	3.1	3.1	71.9
	13.00	3	9.4	9.4	81.3
	14.00	1	3.1	3.1	84.4
	16.00	2	6.3	6.3	90.6
	17.00	1	3.1	3.1	93.8
	18.00	2	6.3	6.3	100.0
	Total	32	100.0	100.0	

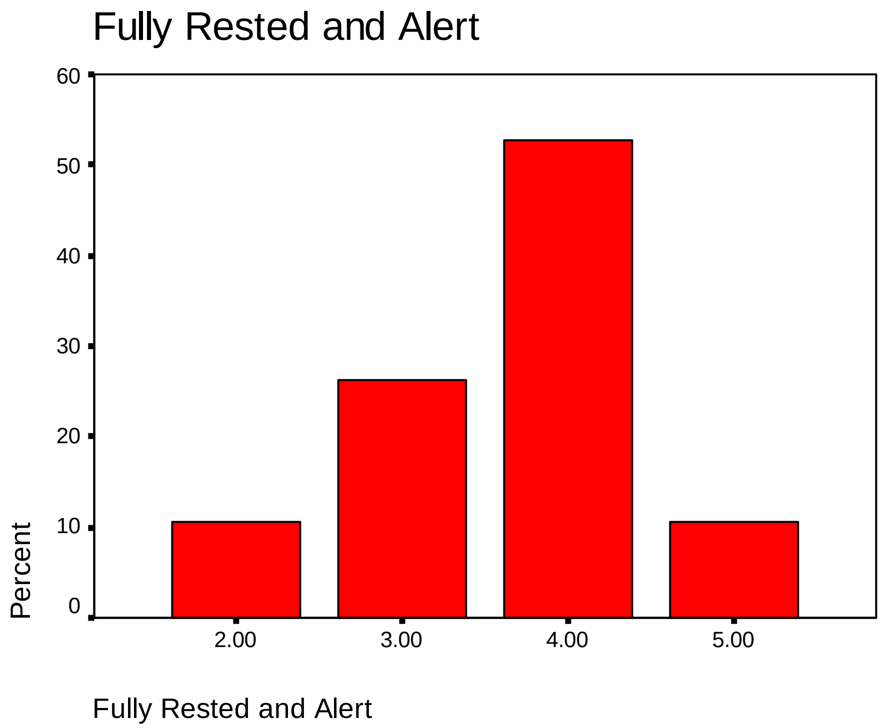
The same data is represented graphically in the chart below.



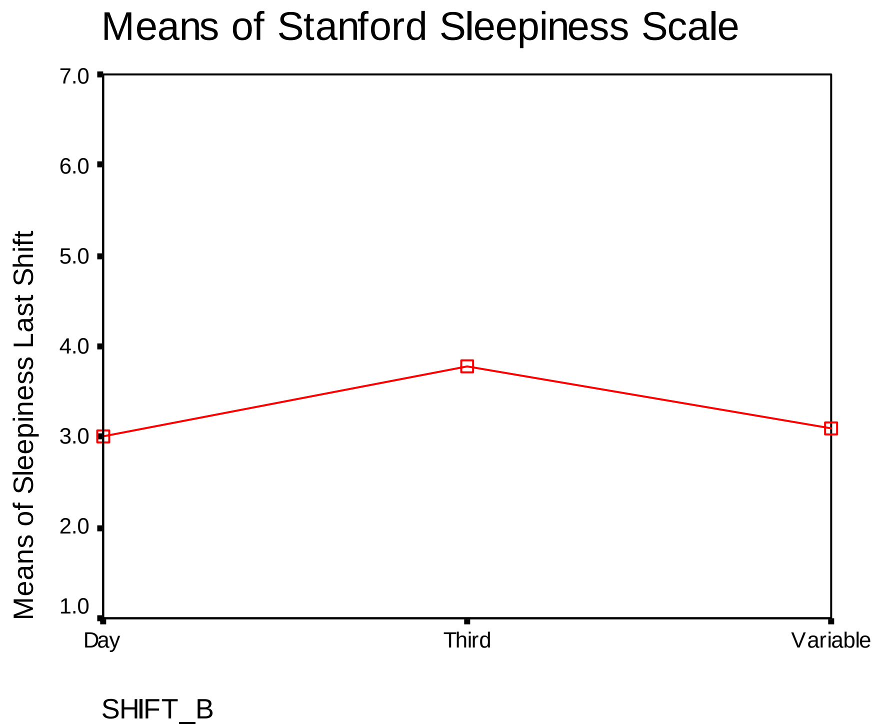
Come to Fully Rested and Alert

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.00	2	6.3	10.5	10.5
	3.00	5	15.6	26.3	36.8
	4.00	10	31.3	52.6	89.5
	5.00	2	6.3	10.5	100.0
	Total	19	59.4	100.0	
Missing	System	13	40.6		
Total		32	100.0		

The above table indicates that there were only 10.5% of respondents at the outset of the study who reported feeling that they reported to work fully rested and alert.

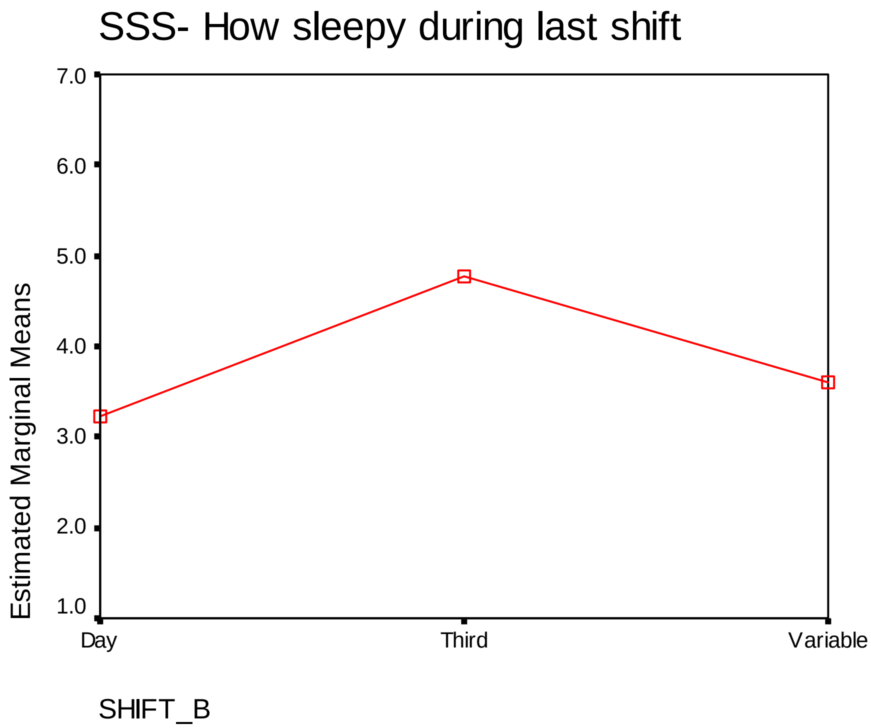


The was however, little difference between the three shifts on the on the average degree of restedness that was reported for the extent to which people felt fully rested and alert.



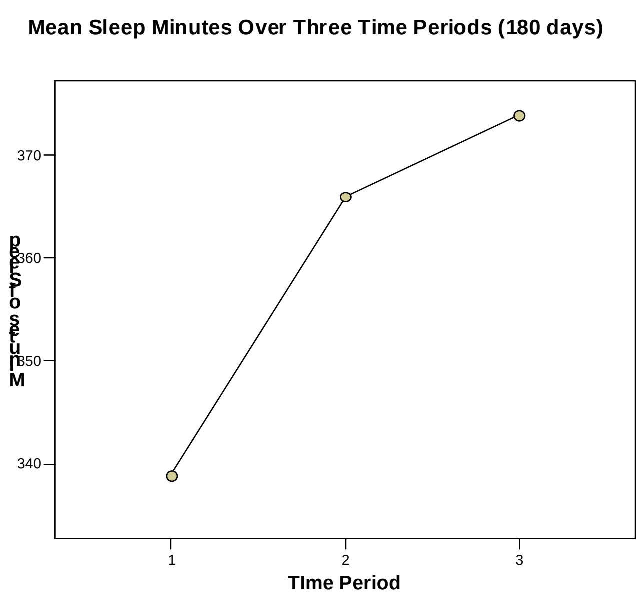
Pretest scores also reveal the fact that the three shifts did not differ significantly on the Stanford Sleepiness Scale. These data are in the expected direction and are most likely the result of the fact that the persons on third shift are in fact able to get the rest that they need prior to beginning their work shift. Note also that Stanford Sleepiness Scale appears to be below the mid-point for the scale suggesting that on average the dispatchers do not appear to have a high level of fatigue. Thus, as far as attempting to address the issues of reducing fatigue, there may be little fatigue to reduce at this point.

Finally, examining the degree to which the respondents were reporting their fatigue level during the last shift it is clear that there were some higher levels of fatigue on the third shift, on average, than for the day shift, as might be expected. This is consistent with the notion that persons working the night shift would have some difficulty dealing with the circadian troughs that would naturally present in the hours between 3 and 5 am.



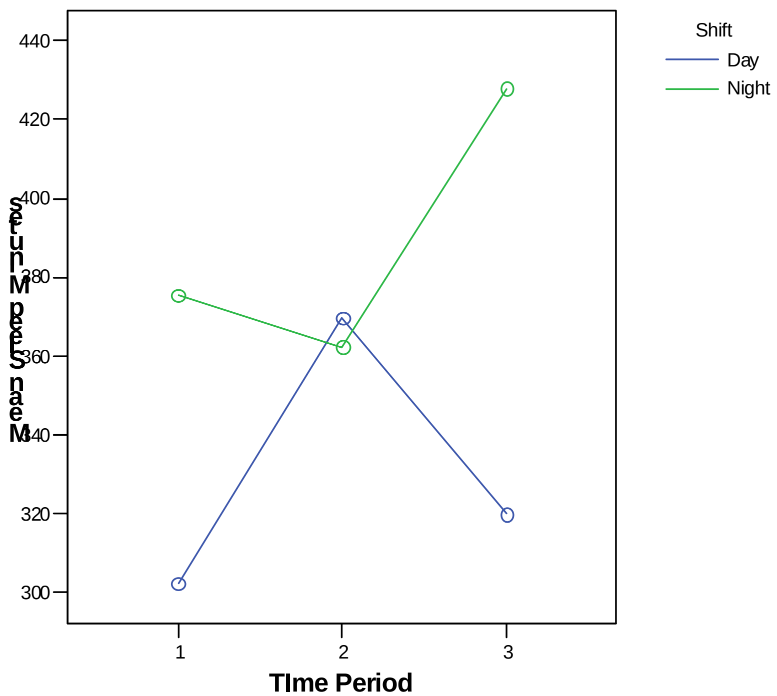
Results of Actigraph Comparisons

As a result of the wearing of the performance actigraphs the average amount of sleep obtained by the persons in the sample increased by almost 10%. This is not statistically significant, however, it is in the predicted direction. Consequently, it makes sense to continue to look at these data and pursue the impact of the fatigue readiness information. The average amount of sleep that the participants obtained



by almost 30 minutes. Again, while not statistically significant due to the small sample size it is a noticeable improvement. An increase of 30 minutes is almost half a sleep cycle and can contribute substantially to feelings of alertness.

Minutes of Sleep at Three Time Periods by Day and Night Shift



Looking at the time one versus time three data we can see that persons who were on the day shifts obtained a higher number of sleep minutes while wearing the performance feedback watches. Surprisingly, persons on the third shift did not increase the amount of sleep they obtained immediately following wearing the watches. However, they did obtain an increased level of sleep during the time after wearing the watches. It may be that third shift employees take a longer amount of time to utilize the information from the watches.

Discussion

Overall, study participants reported that the performance actigraph was a useful tool for fatigue management. While there were no statistically significant differences between the feedback and non-feedback time periods, there were general indications that the feedback component of wearing the watch was related to increases in the amount of sleep participants obtained. Persons on the third shift appeared to first decrease, but later increase, the amount of sleep they obtained. Persons on the day shifts were able at first increase the amount of sleep they obtained but later, they lost the gains in sleep and returned to their pre experimental level.

The inclusion of the coaching sessions with the participants was well received. Unfortunately, the data are limited in terms of the extent to which the coaching sessions actually improved sleep hygiene. On the one hand, several people indicated that they did not feel that they had actually tried to change behavior. They did appear to feel as if they had managed their fatigue as best they could. Thus, they were less motivated to attempt to change their behavior as a result of the use of the fatigue feedback from the actigraph. In general, it was our impression that the individuals in the study were not that distressed by their overall fatigue levels and thus did not show a high degree of motivation to want to change their behavior.

References

Adams, E. (1976). Accident causation and management systems. Professional Safety, 8, 77-81.

Balzer, W., Doherty, M.; & O'Connor, R.. (1989). Effects of cognitive feedback on performance. Psychological Bulletin.

Castellan, N. J. & Swaine, M. (1977). Long-term feedback and differential feedback effects in nonmetric multiple-cue probability learning. Behavioral Sciences, 22, 116-128.

Cole, R.J., Kripke, D.F., Gruen, W.F., Mullaney, D.J., and Gillin, J.C. (1992). Automatic sleep/wake identification from wrist activity. Sleep, 15, 461-469.

Cooper, D. (1998). Improving safety culture. New York: Wiley.

Geller, E.S. (1998). The psychology of safety. New York: CRC Press.

Grant, J. S. (1971). Concepts of fatigue and vigilance in relation to railway operations. Ergonomics, 14(1): 111-118.

Guzzo, Jette, & Katzell, (1985). The effects of psychologically based intervention programs on worker productivity: A meta-analysis. Personnel Psychology, 38(2) 275-291.

Haynes, R. S. Pine, R. C., Fitch, H. G. (1982). Reducing accident rates with organizational behavior modification. Academy of Management Journal, 25(2), 407-416.

Jussim, L., Yen, H. J., & Aiello, J. R. (1995). Self-consistency, self-enhancement, and accuracy in reactions to feedback. Journal of Experimental Social Psychology, 31, 322-356.

Karan, B.S., & Kopelman, R.E. (1987). The effects of objective feedback.

Knipling, R.R., & Olsgard, P. J. (2000). The behavioral power of on-board safety monitoring feedback. Paper presented at the 10th Annual Meeting of the Intelligent Transportation Society of America (ITS America), Boston, May 1-4, 2000.

Krause, T. R., Hidley, J. H., & Hodson, S. J. (1990). The behavior based safety process: Managing involvement for an injury free culture. NY: Van Nostrand-Reinhold.

Markus, H. (1977). Self-schemes and processing information about the self. Journal of Personality and Social, 35, 63-78.

Nease, A. A., Mudgett, & Quinones (1999). Relationship among feedback sign, self-efficacy, and acceptance of performance feedback. Journal of Applied Psychology, 84 (5), 806-814

Petersen, D. (1984). Human error reduction and safety management. New York: Aloray.Psychological Bulletin.

Pollard, J. K. (1991). Issues in Locomotive Crew Management and Scheduling. USDOT Report # DOT/FRA/RRP-91-06.

Reason, J. (1990). Managing the management risk: New approaches to organizational safety. In B. Wilpert and T. Quale (Eds.), Reliability and safety in hazardous work systems. Hove, UK: Psychology Press, Ltd.

Sherry, P. (1992). Peer involvement and behavioral safety: A case study. Paper presented at the annual meeting of the American Association of Railroads Safety Conference, Little Rock, June 8, 1992.

Sherry, P. (1991). Person environment fit and accident prediction. Journal of Business and Psychology, 2, 123-132.

Sherry, P., Bart, S., & Atwater, J. (1997). Distractibility, fatigue, job stress, and accidents in long haul truck drivers. Paper presented at the annual meeting of the Rocky Mountain Psychological Association, Reno, Nevada.

Sierro, S., Boon, M., Kok, G. , & Sierro, F. (1989). Modification of driving behavior in a large transport organization: A field experiment. Journal of Applied Psychology, 74, 417-423.

Sulzer-Azaroff, B. (1982). Behavioral approaches to occupational safety and health. In L. Frederiksen (Ed.) Handbook of organizational behavior management. New York : Wiley.

Sulzer-Azaroff, B. (1982). The modification of occupational safety behavior. The Journal of Occupational Accidents, 9, 177-197.

Swann, W. B. (1987). Identity negotiation: Where two roads meet. Journal of Personality and Social Psychology, 53, 1038-1051.

Swann, W. B., Griffin, J. J., Predmore, S. C. & Gaines, B. (1987). The cognitive-affective crossfire: When self-consistency confronts self-enhancement. Journal of Personality & Social Psychology, 52(5), 881-889.

Waldersee & Luthans, (1994). The impact of positive and corrective feedback on customer service performance. Journal of Organizational Behavior, 15(1), 83-95.

Watson, J.B. (1930). Behaviorism. New York: Norton.

Weller, D., & Sherry, P. (1992). Role of supervisor support in buffering the stress-strain relationship. A paper presented at the APA/NIOSH Conference. Washington, D.C., November 19, 1992.