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Self-monitoring and feedback : reducing the risk of carpal tunnel syndrome in keyboard entry tasks.

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SELF-MONITORING AND FEEDBACK: REDUCING THE RISK OF CARPAL TUNNEL SYNDROME IN KEYBOARD ENTRY TASKS

A Dissertation Presented

by

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ABSTRACT

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The purpose of this study was to decrease the risk of Carpal Tunnel Syndrome (CTS) during keyboard entry tasks through a combination of training, self-monitoring, feedback, goal-setting and reinforcement. A multiple baseline across subjects was used to assess subjects' posture and hand-wrist positions as they entered text on a keyboard. Following baseline data subjects received training and self-monitored either posture or hand-wrist positions. Later feedback, goal-setting, and reinforcement were given on both behaviors in a staggered fashion. The results indicate dramatic increases in both the percentage of posture items performed correctly and the percentage of time hand-wrist positions were at neutral for all subjects. Implications of the results are discussed.

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CHAPTER 1

INTRODUCTION

Occupational health and safety is a major concern of modern societies. One of the most rapidly growing occupational injuries is the carpal tunnel syndrome, which is incorporated in the larger category of cumulative trauma disorders and repetition strain injuries. Professionals in ergonomics, medicine, biomechanics and human factors engineering recently have targeted these injuries as a research priority. Training technologies can integrate the human and mechanical elements and make headway towards the reduction of such occupational hazards and subsequent human suffering. This introduction will summarize the current research in cumulative traumas and present a comprehensive program towards preventing carpal tunnel syndrome (CTS) in video display users by complementing standard engineering with a behavior analytic approach.

Cumulative Trauma Disorders

Cumulative Trauma Disorders (CTDs) are those suffered from the continuous repetitive motions of any part of the body; particularly in the hand, wrist, and arm. Tendons, muscles, nerves, and other soft tissues are targeted as especially susceptible to such injury

(Blair & Bear-Lehman, 1987). A CTD of growing concern in occupational health and safety is the Carpal Tunnel Syndrome. Phalen (1972) reported that CTS is the most frequently reported type of nerve entrapment. Carpal tunnel syndrome differs from the diffuse category of CTD because it is a specific, chronic disease often associated with occupation and from which there is no complete recovery (Ferguson, 1984; Louis, 1987; Mallory, Bradford, & Freundlich, 1989).

Bleecker and Agnew (1987) offer a clear and concise definition of CTS:

> A simple definition of carpal tunnel syndrome is a disorder resulting from compression or irritation of the median nerve as it passes into the hand between the carpal bones and the transverse carpal ligament with subsequent discomfort and impaired use of the hand. The carpal canal is formed by the concave arch of the carpal bones and is roofed by the transverse carpal ligament. These structures form a rigid compartment through which nine tendons and the median nerve must pass. (p. 385).

Epidemiology

A syndrome is a disorder in which the symptoms characterize the disease and serve as subjective evidence of its existence (Jackson & Clifford, 1989). Accordingly, CTS has a definitive set of symptoms associated with it. The symptoms are localized in those portions of the hand innervated by the median nerve; the palmar sides of the thumb, index, third, and half of the fourth finger and the majority of the palm. The symptoms include one or more of the following and are presented in their general order of occurrence: pain (onset often nocturnal and episodic), numbness (paresthesia), tingling, hypo- or hyper- sweating, burning, aching, clumsiness, decreased sensitivity (especially to vibration), edema, and extension of pain and/or numbness through the arm and shoulder (Armstrong & Chaffin, 1979; Bleecker and Agnew, 1987; Feldman, Travers, Chirico-Post, & Keyserling, 1987; Herrick & Herrick, 1987; Jackson & Clifford, 1989).

Diagnosis

Diagnostic methods include Tinel's sign, Phalen's sign (both are based on subject report and observation), vibration threshold testing, thermography and electrodiagnostic testing (see Molitor, 1988, for elaborations). Although there is no one definitive test (Payan, 1988), electrodiagnostic testing offers an assessment of median nerve damage. Average nerve conduction velocity is 35 m/sec and subnormal velocities indicate the presence of some neuropathy (Spitz, 1992). The extent of nerve damage, its cause (such as cellular damage or temporary neuropathy due to edema) and the extent of reversibility are not revealed by the test. Currently, however, it is an invaluable tool in the initial diagnosis of CTS (Jackson & Clifford, 1989; Kimura, 1979; Spitz, 1992).

Risk Factors

Biological. There are many factors which may result in a predisposition to CTS. None of these factors have been established as having a causal relationship with the disease, but all have been highly correlated with its occurrence. The first is gender; females have a higher incidence of CTS than males (Armstrong & Chaffin, 1979; Armstrong, Fine, Goldstein, Lifshitz, & Silverstein, 1987; Clark, 1988; Dieck & Kelsey, 1985). Pregnancy has also been associated with an increased risk of CTS, possibly due to temporary edema (Diek & Kelsey, 1985; Gateless, 1983; McLennan, Oats, & Walstab, 1987; Nygaard, Saltsman, Whitehouse, & Hankin, 1989).

Additional factors may predispose individuals to CTS and similar nerve entrapment syndromes. Histories of arthritis, rheumatoid arthritis, tenosynovitis, and other muscular and joint diseases located in the hand and wrist have been associated with CTS. Diabetes, as well as any history of fractures, tumors, bone disease, or congenital hand defects apparently increase the risk of CTS (Armstrong & Chaffin, 1979; Armstrong et al., 1987; Bleecker, 1987; Browne, Nolan, & Faithfull, 1984; Dieck & Kelsey, 1985).

Biomechanical. The presence of any of the above predisposing factors increases the risk of an individual contracting CTS, but the absence of these factors does not indicate invulnerability. Indeed, biomechanical causes of CTS are the critical factors in the majority of cases (Armstrong et al., 1987; Arndt, 1987; Cannon, Bernacki, & Walter, 1981; Herrick & Herrick, 1987; Nathan, Meadows, & Doyle, 1988; Silverstein, Fine, & Armstrong, 1987; Wieslander, Norbäck, Göthe, & Juhlin, 1989). The most prevalent biomechanical cause of CTS is repetition. Repetitive movements of the hand and wrist directly irritate the median nerve. Forceful exertion (degree of flexion, extension, or weight supported) of the wrist also is a contributor.

In addition to repetition and force per se, other occupational practices have been reliably correlated with the incidence of CTS, especially when combined with repetition. The following have been specified: pinching motions, deviations of normal wrist alignment, work pace, increased muscular tension, exposure to vibration, and constrained or inefficient posture. Other occupationally related correlates with CTS are lack of training, excessive psychological stress, and extreme bonus or incentive systems targeted at high rates of production. The latter are believed to cause employees to dismiss or ignore symptoms of CTS in an effort to meet the incentive requirements (Arndt, 1987; Browne, Nolan, & Faithfull, 1984).

Occupations at Risk

No specific jobs or tasks have been causally related to CTS but it appears that some occupational factors may be partly responsible for the high incidence rates of CTS (Masear, Hayes, & Hyde, 1986). A wide range of tasks carry some risk including keyboard entry tasks. Long hours spent at a keyboard and the highly repetitive specific hand movements appear to be the main culprits (Chapnik & Gross, 1987; Ferguson, 1984; Hall & Morrow, 1988; Kiesler & Finholt, 1988; Stone, 1983).

Technological advancement has now made the manual typewriter virtually obsolete. No longer is an eight hour day of typing interrupted by carriage returns, the changing of sheets of paper, or laborious corrections of typographical errors. Rather, eight hours at a keyboard now often means precisely that. Individuals are making hundreds of thousands of keystrokes each day without the interruptions in motion that standard typewriters once provided. Probably as a result, the incidence of CTS and other related CTDs is markedly increasing in such occupations. It is the believed that the small repetitive motions of the hand and wrist combined with constrained body postures may be the primary contributor to the rise of CTS in VDT workers (Chapnik & Gross, 1987; Hall & Morrow, 1988; Mallory, Bradford & Freundlich, 1989). The angle of deviation of the hand from the wrist is particularly important and can be measured as the angle of deflection between the hand and wrist from a neutral, or flat, position. The most desirable position is that of neutral: the hand is aligned with the wrist and forearm and is neither excessively flexed nor extended.

Medical Treatment

Typically, rest, avoidance of repetitive tasks, and diuretics to reduce swelling are recommended; and, if the problem persists, simple splints that prevent excessive flexion and extension of the wrist are used (Payan, 1988; Schenck, 1988; Schenck, 1989; Sebright, 1986). The injection of steroids into the wrist tissues, and sometimes directly into the median nerve, often reduces swelling and irritation of the nerve (Gelberman, Aronson, & Weisman, 1980; Schenck, 1989). However, steroid injections have complications of their own and may weaken the carpal tendons, result in aesthetic abnormalities, and can chronically inflame the surrounding tissues (Kessler, 1986; Payan, 1988; Schenck, 1989).

Surgery is the final resort if the more conservative therapies are ineffective. The standard surgical treatment severs the transverse carpal ligament which relieves pressure in the carpal canal and reduces the irritation of the median nerve. Never the less, at the present time there is no reliable method for successfully treating CTS, and some of the apparently simple preventive methods proposed (i.e. splints) need to be evaluated with great caution (Habes, 1987). Ultimately, many sufferers are resigned to live with discomfort and drastically alter their daily activities.

Prevention

Current approaches toward prevention of cumulative trauma disorders can be divided into two main categories: ergonomics and training for behavioral change. Blair and Bear-Lehman (1987) stress the need for an integration of these two methods to achieve maximal preventive strategies. Carpal tunnel sufferers can often find relief with relatively simple ergonomic changes in the work environment such as changing the height of a work bench, rotating the angle of a tool, and others (Armstrong et al., 1987; Lutz & Hansford, 1987; Pinkham, 1988), but once these alterations have been made the worker's behavior remains to be modified.

Ergonomics. The primary focus of any program of prevention of CTS, ergonomic or otherwise, is to reduce the incidence of the physical motions which have been associated with its occurrence. The majority of the recommended ergonomic guidelines have the following objectives: The reduction of any excessive force levels; of any extreme joint motions; and of high repetition and/or stereotyped movements (Meagher, 1987; Putz-Anderson, 1988). These objectives are accomplished through the design of work stations, work methods, and work tools. Work stations should be adjustable to accommodate many different body types and incorporate worker position, tool location, chair design, and so on. The design of work methods includes: automation of repetitive tasks when possible; job-task rotation or combination; the use of fixtures rather than the alternative hand to hold materials; and self-pacing and frequent breaks in routine when feasible. Lastly, tool design should maximize the avoidance of extreme and/or awkward joint positions, repetitive finger actions, vibration, and high force. In many cases ergonomic changes are the most direct and cost effective. However, an alteration in the work environment either may not be feasible for a company, or when implemented require behavioral changes along with it. Despite the optimal in environmental design, people may assume hand and body postures that place that at risk. This aspect is best approached by methods designed to modify such behaviors, such as training and management of contingencies of reinforcement.

Training. Training workers to modify their behavior in the workplace may be used as s supplement or even a cost effective alternative to ergonomic changes and for many businesses may be the only option. Even when major ergonomic restructuring of the work environment is recommended (i.e., new keyboards, desks, tools, etc.) organizations may lack the funds to see these changes through. In the best of all worlds, safety issues would not be compromised by economic considerations, however, in the real world that may well be the case. Additionally, if new equipment is brought in, workers still need to be trained to interact in a safe manner with the workstation. In light of this, or else to bridge the time span until new equipment can be purchased, training offers a viable solution. Although training programs are recognized as a necessary measure to reduce the incidence of CTS (Smith, 1987), training needs to go beyond the simple distribution of information to teaching or altering workers' actions.

Training is most critical when subjects are involved in an occupation with inherently high risk of injury. The best option is to ensure that workers perform their jobs safely from the beginning. Otherwise, the challenge becomes more difficult. Especially when maladaptive habits are well established, training alone has been found inadequate. Behavioral literature abounds with studies that clearly illustrate that the modification of behavior is most effectively achieved with systematically programmed contingencies in the environment (e.g. Alavosius & Sulzer-Azaroff, 1986; Chhokar & Wallin, 1984; Komaki, Heinzman, & Lawson, 1980). Therefore, repetitive behaviors such as those under discussion require not only initial training, but also adjustment of contingencies of reinforcement plus an ongoing support systems built into the setting. How to accomplish this is a matter for experimental investigation, yet little has appeared in the literature that explores the impact of training plus behavioral interventions with CTS.

In one pilot study, Blake (1991) developed a system for measuring and modifying behaviors identified as associated with an increased risk of CTS during keyboard entry tasks. These behaviors were comprised of elements of correct posture and hand-wrist deviations. Components of posture and hand-wrist positions were reliably measured and modified in individuals as they used VDTs. Posture improved and the percentage of time hand-wrist positions were at neutral were increased through intensive feedback to the subjects. This demonstrated that the (high-risk) behaviors thought to be risk factors in the evolution of CTS among VDT operators can be modified. The study has provided the basis for the development of a more comprehensive program which may be applied in real work situations.

The conceptual base the aforementioned research employed was applied behavior analysis. The methodologies and techniques have demonstrated enormous success in a wide variety of research, and the field of occupational safety has benefitted greatly through the systematic modification of worker behaviors. The following section reviews the science of behavior analysis and some of the ways in which it has been applied to occupational safety and health.

Achieving Behavioral Change

Behavior analysis, a rapidly growing branch of psychology, has been applied to a wide range of socially important performances (Baer, Wolf, & Risley, 1968; Baer, Wolf, & Risley, 1987). Industry is but one of the settings in which behavior analysis has been found to be extremely useful. Behavioral techniques have long been known to aid in increased productivity and motivation of the workers. Accurate and efficient job productivity also has been enhanced through such methods (Kreitner, Reif, & Morris, 1977; Nadler, Mirvis, & Cammann, 1976). Similarly, Quilitch (1975) and others outside of industry have demonstrated that behavioral interventions can improve the outcome of training programs. Occupational safety, an especially critical aspect of industrial operating, has been found to benefit from behavioral technology is the area of industrial safety (Alavosius & Sulzer-Azaroff, 1986; Alavosius & Sulzer-Azaroff, 1990; Chhokar & Wallin, 1984; Komaki, Barwick, & Scott, 1978; Saari & Naesaenan, 1989; Sulzer-Azaroff & de Santamaria, 1980).

Standard Approaches to Safety. Schaeffer (1976) has emphasized a comprehensive approach to accident prevention that combines epidemiology with increases in industrial safety. Epidemiology examines the relation between the host (human victim), the causal agent (physical, biological, etc.), and the environment. The probability of injury is greatly increased when there is a disturbance in the equilibrium of the above three factors.

Accidents which result in human injury occur when either the host (victim), the environment (i.e., machinery) or both operate in a less than optimal manner. Those resulting from faulty equipment can be prevented through stringent maintenance and sound manufacturing. Injuries sustained due to the human factor may indeed be unpreventable, such as an individual who experiences a stroke while operating an automobile. More often, however, the performance of the individual determines the likelihood of accidental injuries. For example, a worker may neglect to wear proper ear protection during high risk situations (Zohar, 1980) thereby increasing the chance of hearing loss. Human behavior and accidents are linked tightly, and an accident prevention program is incomplete without addressing this critical factor.

Behavioral analysis has been applied to many aspects of job safety including the increase of use of protective eye and earwear (Smith, Anger, & Uslan, 1978; Zohar, 1980; Zohar & Fussfeld, 1981), plus a large assortment of safe behaviors such as proper lifting technique (Alavosius & Sulzer-Azaroff, 1986;

Alavosius & Sulzer-Azaroff, 1990), safe and complete job performance (Chhokar & Wallin, 1984; Fellner & Sulzer-Azaroff, 1984b, Komaki, Barwick, & Scott, 1978; Komaki, Heinzman, & Lawson, 1980) among others. A number of behavioral procedures have combined to achieve those changes. These include, once the specificity of the task has been clarified, feedback, reinforcement, goal setting and self-monitoring.

Analyzing and Clarifying Tasks. Prior to the use of any behavioral intervention, each task must be clarified and operationally defined: this process is called pinpointing. Sulzer-Azaroff and Fellner (1984) provide guidelines for selecting performance targets in the behavioral analysis of occupational health and safety, including social importance and practicality. Performance targets, or pinpoints, should meet the following criteria: they are observable; can be reliably measured; are under the performer's control; and are directly related to the target performance (Daniels, 1989). All of these factors, in addition to the ergonomic and medical literature, were considered in the selection of posture and hand-wrist positions in the current study.

Reinforcement. Reinforcement is perhaps the most basic behavioral principle. Reinforcement is the process that takes place when a reinforcer is delivered contingent upon a behavior and the behavior strengthens. Affected dimensions of the behavior may include rate, duration, intensity and maintenance (or continuation) of the behavior. Depending on the individual's prior learning history and current circumstances, reinforcers vary in strength and may consist of individual activities, social events (i.e., praise) or tangible items. The literature abounds with demonstrations of the enormous power of reinforcement applied to numerous populations and behaviors. Reinforcement may be automatic, or intrinsic to a task: when a soda machine is operated properly the individual receives a soda. Therefore, the behaviors required to operate the machine are reinforced and strengthened. Some tasks, however, have no inherent reinforcing properties (or if they do, they occur far in the future). In these cases, reinforcement may be formally programmed into the relation between the performance and its consequences. Behavioral approaches to occupational health and safety often include reinforcement. See Sulzer-Azaroff and Blake (in press) for an extensive list of the use of feedback, reinforcement and goal setting (discussed below) in occupational health and safety programs.

<u>Feedback</u>. Many of the successful behavioral studies in industrial safety have shared a common theme - feedback. Feedback is an extremely effective method for achieving behavioral change (Balcazar, Hopkins, & Suarez, 1986; Emmert, 1978; Ford, 1984; Frederiksen, Johnson, & Solomon, 1982; Karan & Kopelman, 1986; McCuddy & Griggs, 1984; Prue & Fairbank, 1981). Prue and Fairbank (1981) have highlighted the advantages of feedback. Feedback is a relatively low cost route to behavioral change when compared with other methods such as extensive incentive systems. Implementation of feedback techniques is fairly simple and relatively easy to teach to managers. It is flexible and thus available to virtually all settings regardless of their size. Finally, the emphasis which feedback, as conventionally practiced by applied behavior analysis, places on positive aspects of behavior is thought to decrease unsystematic aversive control. Balcazar, Hopkins and Suarez (1986) found that feedback was most effective when supplemented with reinforcement and goal setting.

Self-Monitoring. Initially developed as a clinical tool, is self-monitoring is a cost effective way of incorporating rapid feedback and sometimes reinforcement into a program of self-directed behavior change in any setting (Kanfer & Schefft, 1988; Kazdin, 1974a; Kopp, 1988; Kopp, 1989; Sulzer-Azaroff & Mayer, 1991; Thoreson & Mahoney, 1974). The subject discriminates whether or not a target behavior has occurred and, based on this information, records either the presence or absence of that behavior. The process is highly reactive: "...of particular relevance to behavioral observation, is reactivity--the phenomenon in which an assessment procedure results in modification of the behavior of subjects being assessed." (Haynes & Horn, 1982, p. 369-370) Thoreson and Mahoney (1974) have recognized the role of reactivity in self-administered procedures such as self-monitoring. Basically, "When an individual attends to, records, or otherwise observes his own behavior, there is often a subsequent change in that behavior" (p. 29). Reactivity, and the entire self-monitoring process, greatly increase the salience of established environmental contingencies on a given behavior. As such, the behavior may be modified by the very process which is measuring it. The extent to which behavior changes can be maximized by structuring the self-monitoring in specific ways.

Based on an extensive review of the literature, Blake (1992) identified several components of self-monitoring that significantly influence its impact on behavior. These factors are: levels of motivation, expectancies and desirability of the target behavior, target behavior topography, recording parameters and levels of external surveillance. Further, these factors were examined within the context of a business setting.

Research has shown that increased levels of motivation result in increased magnitudes of reactive change in the target behavior (Belfiore, Mace, & Browder, 1989; Kanfer & Schefft, 1988; Komaki & Dore-Bryce, 1978; Kopp, 1988; Lipinski, Black, Nelson & Ciminero, 1975; Thoreson & Mahoney, 1974; Watson & Tharp, 1972). Self-selection of the target behavior and/or knowledge of the benefits of changing the behavior both increase motivation.

The desirability of the behavior will also influence the degree of change. The direction of change (either and increase or a decrease) will reflect the expectancies placed on the behavior (Baskett, 1985; Belfiore, Mace & Browder, 1989; Willis & Nelson, 1982). These expectancies can be enhanced through direct communication of the benefits of changing the behavior. For example, knowledge of the risk involved in unsafe behaviors (such as failure to wear protective eye glasses) may increase the reactivity of the process, and subsequently, the magnitude of change.

Another factor which affects the success of self-monitoring is target behavior topography. Data suggest that overt motor behaviors often are easier to discriminate than covert responses. Additionally, motor behaviors demonstrate more change than verbal behaviors (Kopp, 1988; Willis & Nelson, 1982). Discrimination of the target behavior and subsequent recording are more probable with increased salience and memorability of the behavior (McFall, 1977). Successful discrimination of the response is also key to recording it.

Recording components also influence the degree of change yielded through self-monitoring and include: the type of recording device, recording schedule, frequency of recording, the place where recording occurs, proximity of the recording device and latency between the response and the recording. The more obtrusive the recording device is the greater the reactivity, and therefore, the greater the behavioral change (Belfiore, Mace, & Browder, 1989; Kanfer & Shefft, 1988; Kopp, 1988; Watson & Tharp, 1972). One method of increasing the salience of the device is to place it in a close proximity to the occurrence of the response as possible. This increases the likelihood that the behavior will be discriminated and recorded.

Once discriminated, the behavior should be recorded as soon as possible. In addition, the more often the recording response is made, the more reactive the process, yielding an increased rate and magnitude of change. Therefore, the most dense schedule of recording feasible within the constraints of the setting should be undertaken.

Finally, external surveillance is extremely powerful in maximizing the effects of self-monitoring (Kopp, 1988). Subject knowledge that another individual (therapist, experimenter, family, peers, etc.) is aware of the self-monitoring will increase the likelihood of behavioral change in the desired direction. The effects of external surveillance are most powerful when direct contact is established between the subject and the external person. However, the mere notion that surveillance exists is sufficient to influence the efficacy of the program.

The issue of accuracy (i.e., concurrence with more objective and valid experimental data) of self-monitoring needs to be addressed. Kopp (1988) and Thomas (1976) report that self-monitoring subjects are fairly accurate when matched against the recording of observers. However, even inaccurate self-recording has been found to promote desired change, although increased accuracy often increases the magnitude of behavioral change (Baskett, 1985; Hayes & Nelson, 1983; Kanfer, 1970; Kopp, 1988; Willis & Nelson, 1982). Accuracy can be enhanced by providing the subject with formal discrimination training of the target behavior. Yet, the most straightforward and demonstrable method of increasing accuracy is to provide feedback to subjects about their accuracy.

Numerous classes of behaviors and populations have benefitted from self-monitoring. To illustrate, Schloss, Smith, and Schloss (1988) and Whitney and Goldstein (1989) demonstrated that verbal behaviors such as aphasic dysfluencies and the use of specific parts of speech could be modified successfully with self-monitoring. Performance on the job has been improved in both typical and developmentally delayed populations (Burgio, Whitman & Reid, 1983; Feeney, Staelin, & O'Brien, 1982; Gaetani, Johnson & Austin, 1983; Herren, 1989; Komaki, Waddell, & Pearce, 1977; Mirman, 1982; McNally, Kompik & Sherman, 1984). This tool can also be applied to performances surrounding safety in industry.

Although many different methodologies have been applied in organizations, self-monitoring has several features which make it especially attractive. Following initial training costs, self-monitoring is relatively inexpensive and can intermesh nicely with peer-mediated programs. For example, peers can provide important feedback, reinforcement and external surveillance. Time and monetary costs to management can be minimized and employee "ownership" of the program may significantly enhance the results. All of these factors were considered in the design of the current research.

Goal-Setting. Goal-setting is another tool that can add significantly to a behavioral change program. Goal setting involves the selection of a challenging yet attainable level of performance. Reinforcement is delivered contingent upon the attainment of the goal. Often, performance require a series of sub-goals which gradually reach a terminal goal (i.e., 100%). A general rule is that goals are set toward the upper limit of previously measured performance. Fellner & Sulzer-Azaroff (1984) and others (Erez, Early & Hulin 1985; McCuddy & Griggs, 1984; Reber & Wallin, 1984; Sulzer-Azaroff & Mayer, 1991) have illustrated the utility of goal-setting in industrial organizations. Goal-setting is most effective when combined with feedback and reinforcement and allows the individual to participate in goal selection. Subject participation in behavioral programs can result in extremely powerful and lasting change. Self-monitoring is an example of this and incorporates the procedures discussed above.

Purpose of Present Study

The purpose of the present study was to attenuate the risk associated with keyboard entry tasks and which presumably should ultimately reduce the incidence of CTS in the subject population. This purpose was to be met integrating ergonomics, biomechanical and medical approaches with intensive behavioral training. Four sub-goals were addressed toward this objective: 1) to apply and demonstrate the reliability of the basic system targeted at posture and hand-wrist positions developed during pilot work (Blake, 1991) to subjects who work at a keyboard in an applied setting; 2) to demonstrate substantial improvements in the target behaviors through the systematic implementation of a package consisting of training, self-monitoring, feedback, reinforcement and goal-setting; 3) to assess and promote transfer of the learned skills from the laboratory to the natural work environment throughout all intervention procedures; 4) to assess and promote maintenance of the learned behaviors in the natural work setting. This final goal will continue to be realized far into the future, and it is intended that data be collected for up to a year following completion of the formal study.

The experimental questions were as follows: Was the combination of training, self-monitoring, feedback, reinforcement and goal-setting effective in yielding substantial behavioral change and, presumably, a subsequent reduction in the risk of CTS in the subject population? Will these changes transfer to the natural work environment and will they maintain over time? To meet this goal, components of posture and hand-wrist deviations were selected as dependent variables.

Although the degree of force and repetition have been demonstrated as strong contributors to CTDs, practical limitations in the study precluded their measurement. A package of training, self-monitoring, feedback, reinforcement and goal-setting was the independent variable.

Subjects were videotaped as they entered text on a computer keyboard in a laboratory setting. Following baseline measures the interventions were introduced sequentially in a multiple baseline design across subjects. It was anticipated that the most optimal performance would be exhibited through a coordinated package of all the independent variables and that transfer of the skills to natural work environment would be demonstrated.

CHAPTER 2

METHOD

Subjects

Subjects were 6 female secretaries ranging in age from 26 to 58 years and employed full time in the Psychology department at the University of Massachusetts. All subjects performed keyboard entry tasks as part of their regular job duties. A staff meeting was held during which all secretaries in the department expressed a willingness to participate. The subjects were selected from this pool based on recommendations from the secretarial supervisor.

Informal interviews with the experimenter were conducted to determine who would be suitable for the study (i.e., someone who was scheduled to leave for several weeks during the study was not included; subjects' offices needed to be available for generalization and maintenance probes). To avoid sampling bias, subjects were screened prior to participation to ensure that they did not display any predisposing factors which might increase the inherent risk of CTS (see Nerve Testing). All voluntarily participated and gave written informed consent (see Appendix A) and confidentiality was assured. Each subject was offered \$100.00 divided over the course of the study and a \$100.00 bonus contingent upon completion of the study. In actuality, 4 of the 6 subjects elected to receive \$200.00 in a lump sum at the end of the study. All completed the study.

Nerve Testing. The NeuroSentinal Testing Unit was used to measure the nerve conduction velocity (m/sec) of subjects' median nerves. Occupational Preventive Diagnostics, Inc. (OPD) provided the device and analyzed and interpreted the data. The unit was portable, tabletop operated and powered by a 12 DC volt battery. The NeuroSentinal Unit has the Food and Drug Administration FDA-510K approval which permits non-medical personnel to administer the test. The experimenter was trained by OPD to operate the equipment. The procedure involved using non-invasive surface electrodes which produced a small electric pulse and took approximately 10 minutes. The pulse caused subjects to experience a slight tingling sensation.

Nerve testing of both hands of all subjects was performed on subjects prior to any data collection. The results of the test were combined with general physical information about each subject (see Appendix

B). These data provided an estimation of subject risk for CTS as characterized by Occupational Preventive Diagnostics, Inc. This screening indicated that all subjects were categorized as "LOW RISK" and all were allowed to continue participation in the study.

Setting

The experimental setting was a laboratory in the Psychology Department on campus. The layout allowed the experimenter to videotape subjects' hand and body positions as they entered text on a computer keyboard and to provide feedback privately to each subject. The office was approximately 4 x 3.3 meters and two large windows occupied the outside wall. Various office furnishings and research equipment (bookcases, filing cabinets, stationary video camera, video cassette recorder and monitor, etc.) were in the room. The only individuals present during sessions were the subject and the experimenter. See Figure 1 for an illustration of the experimental setting.

Apparatus

Workstation. An International Business Machines Corporation (IBM) compatible personal computer with monochrome screen was used to operate the WordPerfect 5.1 word processing program. The program allowed the user to input text and displayed it onscreen as it was entered. The keyboard was placed at a height of 69 cm from the floor and the monitor was at each operator's eye level. A chair was provided in front of the screen that subjects could adjust to change the seat height and pitch and the back pitch. A small platform (38 x 11 x 23 cm) was available to the subjects as a foot rest.

Text. Text was placed on a standard typist's stand but subjects were free to move the text to a location most comfortable for them. The text was selected from various sources (books, magazines, etc.) and its level of difficulty was approximately that of an introductory college textbook.

Video Equipment. A JVC Company of America camcorder (model # GR-AX5) affixed to a stationary tripod was used to videotape subjects; a monitor and video cassette player to view tapes. A Sony Walkman Cassette player provided auditory cues defining each observational interval to observers during videotape scoring and during *in vivo* observations in subjects' offices to assess generalization and maintenance. A stopwatch was used to time each experimental session.

Scoring Procedures

Personnel. The author acted as the primary observer and provided all feedback and a research assistant (RA) conducted reliability observations. The RA was an undergraduate who successfully had completed a course in methods of scientific research and she earned psychology course credits for her work. The author trained the RA and informed her of the general purpose of the study but kept her naive as to the intervention. The RA was not present during experimental sessions or feedback delivery.

Dependent Variables. The main dependent variables measured were 1) percentage correct posture components 2) percentage of correct hand-wrist position and 3) entry rates of keystrokes and words per minute. The first two measures were collected through observation of experimental sessions on videotape (see Appendix C for behavior checklists). The third measures were calculated immediately following each session. The number of words per minute was calculated by dividing the number of words typed by the duration of typing (a stopwatch was used to record the exact duration of straight typing). A rough estimation of keystrokes per minute was calculated: number of bytes - 326 (bytes required to format document)/minutes.

According to the Human Factors Society (ANSI/HFS, 1988) and Green, Briggs and Wrigley (1991) correct posture had 5 critical features. 1) Back Straight: spine at an 85-95 degree angle with the floor. 2) Shoulders relaxed: line of shoulders not hunched upwards toward the neck or over the chest; shoulders forming an even letter "T" with the spine, each shoulder at the same height; a line connecting both shoulders should be parallel with the floor, perpendicular to the spine. 3) Neck aligned with back: head held up, chin not in contact with either shoulders or chest, neck a continuation of the spine, head oriented toward either the VDT screen or to the text. 4) Feet flat on floor: both feet touching the floor or platform with both the heels and toes, legs not crossed; thighs parallel with the floor. 5) Forearms parallel to floor: Both arms from elbow to wrist parallel with the floor.

Correct hand-wrist position measured the following deviations from neutral (angle of the joint between the hand and wrist at its midpoint) as described by Putz-Anderson (1988, p. 54):

Extension - bending wrist up and back.

Flexion - bending the wrist down towards palm.

[Data collected during pilot research (see Blake, 1991) indicate that, in general, flexion-extension were the primary deviations from neutral during keyboard entry tasks. Ulnar and radial deviations (moving the hand side to side in a lateral plane) seemed not to be significant in the sort of keyboard entry of concern here, although they are probably prevalent in related VDT tasks such as the operation of a mouse.]

The third set of main dependent variables was the rate of data entry and included Words Per Minute (WPM) and Keystrokes Per Minute (KPM). This was a corollary measure only; it was not targeted by the intervention nor did subjects receive feedback on it. Rather, it served to monitor the effect any changes in the first two dependent variables (posture and hand-wrist position) may have had on keyboard entry rates. The measure was selected because keystroke rates often are monitored in actual work settings, and any effect the intervention may have had on this productivity measure would need to be considered if an organization were to consider adopting these procedures.

Consumer satisfaction information was gathered from each participant (see Appendix F). Subjects were asked to rate different aspects of the experimental procedures and also provide overall feelings regarding their participation in the study.

Observer Training, Supervision and Calibration. Observers learned to score the dependent variables reliably by practicing on videotaped samples. The samples depicted individuals typing at the computer and were divided into two categories: wide angle shots to evaluate posture and focused shots for the evaluation of hand-wrist positions. Training took approximately six hours and was completed in three sessions. The two observers discussed the observational definitions and concurrently observed several samples of about 10 minutes in length. The RA continued to record segments of the tape in this way and periodically was joined by the experimenter to assess interobserver agreement.

Percentages of overall agreement were computed by dividing the number of observer agreements by the number agreements plus disagreements and multiplying by 100. Any disagreements were discussed and the operational definitions consulted until both observers agreed upon the debated interval. The RA was considered trained when 10 consecutive 10 minute samples yielded interobserver agreements (IOAs) of no less than 80%. This criterion was used for observations of both posture and hand-wrist positions. Interobserver agreement was assessed throughout the study and it was planned that if the index were to fall below 80% at any time, recalibration would occur. This was not required.

Data Collection. Videotapes of each experimental session were viewed. Using tape recorded auditory signals, posture was recorded for 20 10-second intervals, hand-wrist positions for another 20 10-second intervals.

Whole interval recording was selected for the 5 posture components because the behaviors were supposed to occur without interruption throughout the interval. Consequently, the behavior was observed for 10 seconds and results recorded (on a checklist) as + (present) or - (absent) within the next 5 seconds (see Appendix C). Each individual posture component was checked as *present* if and only if it occurred without interruption throughout the full duration of the interval; otherwise it was checked as *absent*. Each trial consisted of 20 such intervals for a total of 100 (5 components / interval x 20 intervals).

Observations of the hand-wrist positions were conducted according to a Momentary Time Sample (MTS) procedure, with each hand observed separately. The behavior was observed and scored at the exact moment a 10 second interval ended. The MTS technique was selected because pilot research revealed that the behaviors occurred at an extremely high rate and frequency counts would be unwieldy and inaccurate. The short interval MTS technique had been shown to estimate accurately the percentage of time a high frequency behavior occurs (Saudargas & Zanolli, 1990). Each session consisted of 10 intervals for each hand for a total of 20 (10 intervals/hand x 2 hands).

Interobserver Agreement. The primary observer and the RA, cued by the same audio signal, conducted observations simultaneously to estimate the reliability of the system. Percentages of overall agreement were computed in the manner described above. Observers were positioned so that neither could observe the other's recording. Over the course of data collection, 21 (18%) of baseline sessions, 11 (16%) of Phase I sessions and 21 (24%) of Phase II sessions were checked for reliability for a total of 53 (20%) of all sessions combined. The overall mean percentage agreement as calculated on a component by component basis for posture was 98.9% (with a range of 80% to 100%) and for hand-wrist position was 90.6% (with a range of 80% to 100%). Table 1 shows agreement scores for each subject by condition.

Limited assessment of interobserver reliability on probes taken to assess transfer of skills was due to constraints within the system. Subjects' offices did not readily accommodate the videotaping of probe sessions, thus necessitating live observations. The RA's schedule did not coordinate with subjects' work schedules until the end of the study at which point IOA was gathered for the final 2 probes for each subject. During one instance the RA and the experimenter independently conducted probes on the subjects at separate times during the same day. These were not included in IOA calculations but are indicated on the appropriate graphs in the Results section. The mean percentage agreement for probe sessions was 97.5% with a range from 85% to 100% (see Table 1).

Experimental Design

A multiple-baseline across-subjects design was used. The 6 subjects were divided randomly into 2 groups according to which of the two classes of behavior they were to self-monitor: Self-Monitoring Posture group (subjects SP 1, SP 2 and SP 3) and Self-Monitoring Hand-Wrist group (subjects SH 1, SH 2 and SH 3). Figure 2 diagrams the sequence of events for each group of subjects.

Each subject began in baseline and received the interventions in the sequence provided (see Figure 2). Each intervention was introduced to permit a sufficient lag in baseline time from the previous subjects' and when performance stabilized in the previous intervention. Stability was defined as no new high or low points for at least 3 consecutive sessions. The number of sessions of baseline and phases of intervention are provided in Table 2.

The experimenter adhered to detailed logs and a written daily sequence of events for each subject. Written and verbal instructions, subjects' current interventions and any other pertinent information were recorded to organize the complicated procedure. The experimenter also took daily notes and recorded any significant events or communications with subjects.

In-office probes were arranged in a similar manner. Subjects were informed that weekly probes would occur in their own offices. The layout of each subject's office was unique, however all contained desks, chairs and at least one computer terminal.

Procedures

Initial Orientation. During the initial daily sessions of approximately 15-20 minutes, subjects entered the lab and made themselves comfortable at the computer station. Subjects were familiarized with the laboratory layout, workstation and the operation of the chair during the first session. Any questions or concerns about the video equipment were addressed at this time. The experimenter provided the following verbal instructions:

> Please seat yourself at the keyboard and adjust the workstation as you like. You may move the text wherever you find the most comfortable. When I say "BEGIN" please enter the text *as if you were typing for a job assignment*. For instance, if you normally correct errors as you go along, do so

here; capitalize where it is appropriate and underline, indent, etcetera according to the text. I am not interested in how well you type, nor am I counting errors. Please continue typing until I say "STOP". I am going to be in the room during the session, but we cannot speak once the taping begins. If you have any questions or concerns you feel are very important, you may stop typing and ask - otherwise, do not stop until I tell you to.

Daily Sessions. The subject seated herself at the keyboard and adjusted the equipment (location of keyboard and text, position and height of chair) at the start of each session. The experimenter said "begin" and the subject entered the provided text on the keyboard while the experimenter initiated videotaping. A wide angle shot was used to record posture. This provided a view of the entire subject from her left side. All components of posture (head, neck, arms, back and feet) were visible on the tape.

A focused shot was used to record hand-wrist positions. Subjects were asked to remove any jewelry or roll up their sleeves if they prevented a clear view of her hands and wrists. A view of the right and left arms, hands and wrists was taped. Each was taped while typing for 6 minutes (occasionally this duration would be slightly shorter or longer by a few seconds). The subject stopped typing when the experimenter said "stop" and taping ended. Dependent upon the experimental condition, the subject either left the office at this time or engaged in an intervention activity. The experimenter sat at the side of the room opposite from the subject and was present throughout the entire session but did not communicate with the subject during taping (see instructions above).

Baseline. Data were recorded for each subject but no information about findings was shared with the subjects. Data were recorded for a minimum of 10 sessions and until stability was reached for the class of responses to be self-monitored. Criterion for stability was at least 3 consecutive data points remaining within the range of previous sessions (no new highs or lows for three sessions). This stability standard was used throughout the remainder of the study.

Training and Self-Monitoring

The multiple baseline format made it necessary to restrict communication between subjects to prevent any unintentional generalization of the data as subjects entered different phases at different times. At the start of intervention and several times during the study subjects were asked to avoid discussing with their co-workers the experiment. Anecdotal reports suggested that subjects complied and even enjoyed "keeping a secret" about the research.

Discrimination Training. After the termination of baseline and prior to the beginning of the first session of Self-Monitoring, subjects were provided with the training package (see Appendix D). The package was designed to maximize the value of self-monitoring by assuring that subjects could identify and discriminate correct from incorrect responding. It provided detailed information on CTS and included: definitions, symptoms, predisposing factors, possible causes, treatment and prevention methodologies and suggestions for safe, comfortable working conditions. Correct posture and hand-wrist position were outlined and definitions of the components provided. The package included an illustrated 10 x 14 cm laminated card which summarized the components of correct posture and hand-wrist position (see the last page of Appendix D). Subjects were instructed to place the card in a highly visible location in their office next to their own keyboard. (Subsequent observations revealed that all subjects complied.) This card was also displayed in the laboratory for any subject in this condition. The card was removed for subjects still in baseline.

The experimenter then met with the subject to review the training materials and discuss and answer any questions. Next, each subject was shown a series of photographs which depicted an individual seated at a keyboard. The pictures provided combinations of correct or incorrect posture components. A sample picture showed correct head, neck and back combined with incorrect feet and arms. The subject was asked to determine whether each component was correct or incorrect. The subject and experimenter scored two samples together and discussed each component. The subject then scored ten pictures and received immediate feedback from the experimenter on each and any errors were discussed. All subjects met the minimum of 80% correct required for subjects to demonstrate mastery and proceed with Self-Monitoring. An identical procedure was used to train subjects in the discrimination of hand-wrist positions. The results of the discrimination training for each subject are presented in Table 3.

Self-Monitoring. At the beginning of the first data-collection session after Training, the experimenter introduced the self-monitoring form to the subject and instructed her as to its use. Subjects in the Self-Monitoring Posture Group (SP 1, SP 2 and SP 3) were given only the Self-Monitoring Posture Form (SMP form) and subjects in the Self-Monitoring Hand-Wrist Group (SH 1, SH 2 and SH 3) were given only the Self-Monitoring Hand-Wrist Form (SMHW form). Appendix E shows an example of each form. (Subjects monitored only one class of behavior throughout the study to determine if there were any differences in the effects of self-monitoring between posture and hand-wrist responses).

The forms were placed on the desk directly to the side of the keyboard and were fully visible. At the end of each session, subjects were asked to estimate the percentage of time during the session that they engaged in the correct behavior. For example, if the subject believed that her feet were flat on the floor for about one-half the time, she recorded 50% for that component. The experimenter stressed to each subject that she was to make a rough estimation. No feedback on the accuracy of self-monitoring was provided nor was any information on baseline or current performance provided.

Each subject continued to self-monitor her assigned behavior (either posture or hand-wrist position) until her performance stabilized, then the next intervention (feedback, reinforcement and goal-setting) began.

Feedback, Reinforcement and Goal-Setting

Feedback about previous performance occurred at the beginning of each session before videotaping began. Subjects continued to self-monitor their assigned behavior in the same manner as before, but in addition feedback (FB), goal-setting (GS) and reinforcement (R+) also were provided. Subjects only received FB, GS and R+ on the behavior which they self-monitored and did not receive any on the other set of behaviors. After 3 sessions of this procedure, FB, GS and R+ were also introduced on the behavior not self-monitored (for one subject, SH 1, four sessions were used instead of three to establish stability). This allowed any "spontaneous" generalization of FB, GS and R+ from one class of behavior to the other to be assessed. (See Figure 2 for the flow diagram of the procedures.)

Feedback. Dependent upon which class of behaviors (posture or hand-wrist) feedback was based on, feedback consisted of informing the subject about either her percentage of correct posture items per session or the percentage of time hand-wrist positions were at neutral. A large colorful graph was presented to each subject and included all data up to that point. Self-monitoring data were included on a transparent overlay on the appropriate graph. (In this way, either experimental or self-monitoring data could be viewed independently or together.) This provided subjects with feedback on the accuracy of their self-monitoring (the extent to which self-monitored data concurred with experimental data). Accuracy, however, was not focused on. The experimenter stressed improvements from baseline as a result of self-monitoring regardless of accuracy.

Goal-Setting and Reinforcement. During GS the experimenter explained goal-setting and guided the subject in choosing an appropriate goal level for each behavior just after FB had been provided. Goal-setting instructions were as follows:

Now that you can see how you have been doing, I'd like you to select a goal that you can try to reach. We want to be certain that reaching the goal is possible, so let's pick a level towards the top of your previous performance - something that you have done before. (For example, over here you reached 65% three times! Most of the points are 60% or under, so let's pick 60% or 65%. - the subject would then select a goal level) Now that you have picked a goal, draw the line on the graph where it is so you can tell when you reach it.

Initially, goals were set no higher than the highest data point within the previous sessions. Goals levels were changed when the pre-specified level had been achieved or exceeded for at least 3 consecutive sessions.

Posture data reached the optimal level for all subjects prior to the introduction of FB, GS and R+. Therefore, the only reasonable goal was a maintenance goal of 100%, and all subjects selected this.

The experimenter provided the subject with enthusiastic approval and social praise for her progress and for attaining goal levels. Smiles, verbal encouragements and other positive social interactions were used.

Mastery Criteria. The interventions continued until the subject attained at least 90% for at least 3 consecutive sessions for posture. Due to time constraints and a limited number of possible sessions, interventions ceased when hand-wrist data stabilized at a level substantially higher than that of baseline.

At the conclusion of each subject's participation, arrangements for payment were made and the consumer satisfaction survey was given to her. The experimenter told the subject that her opinions and feelings about the study were important and to be as honest as possible on the survey. Names were not required and the surveys were returned in the experimenter's mailbox.

Transfer and Maintenance

All probes occurred in the subjects' offices while they were using their own equipment to enter text. During probes, the specific textual materials varied dependent upon the subject's current job assignment. It was not possible to measure WPM or KPM during probes.

Transfer/Cross-Setting Replication Probes. Probes were taken for baseline and each intervention in each subject's normal work environment. The experimenter and/or the RA conducted live observations and used the same scoring methods as those used with the videotapes. Auditory cues were provided to the observers privately with headphones so that subjects were unaware of the recording intervals. Probes were taken for 20% of all session for each subject. The probes were distributed evenly throughout all phases (this resulted in a schedule of approximately 1 probe for every 5 laboratory sessions). Probes were scheduled weekly with each subject. The observer entered the office and watched the subject as she entered text on her keyboard. If the subject was not currently typing as part of her job, she accommodated the experimenter by typing any available text regardless of job relevance. Often, a subject would "save" some work up to do during the probes.

Following the cessation of baseline the probes were no longer "generalization" but were cross-setting replications because the parts of the interventions were also used during these sessions. Feedback and reinforcement conditions surrounding each probe mimicked the experimental conditions the subject was receiving at that time. For example, baseline subjects received no feedback on the probes. If a subject were receiving feedback for a given class of behavior during experimental sessions she would also receive feedback about the probe data. Goal setting and SM were not used because, based on the data, this limited intervention in the natural setting was sufficient to produce a change and a more intensive replication of the interventions was not required.

Maintenance. Maintenance of the behaviors will be assessed following the cessation of intervention. Probes will be conducted in a similar manner as during transfer probes and will continue for a minimum of several months. No interventions will be used during these probes. The RA has been contracted to conduct these probes in the experimenter's absence. Probes will be unannounced and will be taken twice per month per subject for as long as is feasible.

Table 1. Percentage of Interobserver Agreement Per Session for Each Subject by Condition: Self-Monitoring (SM), Feedback, Goal-Setting and Reinforcement (FB/GS/R+).

	Posture			Hand-Wrist Position		
Subject	Baseline	SM	FB/GS R+	Baseline	SM	FB/GS R+
SP 1	100	100	100	85	95	100
	100	100	100	100	85	90
	100		100*	89		100*
			100*			85*
SP 2	100	100	100	80	100	100
	100		100	100		100
	95		100*	90		100*
	100		100*	90		100*
SP 3	99	100	100	95	80	95
	100	100	100	85	100	100
	80		100*	85		100*
	100		100*	90		100*
SH 1	100	97	100	100	100	90
	100	100	100	95	80	100
	100			90		
SH 2	100	100	100	100	100	80
	100	100	100	100	90	80
	100		100*	100		85*
			100*			90*
SH 3	80	95	100	85	80	90
	93	100	100*	85	100	100*
	100		100*	85		90*
	100			85		

* Indicates reliability on transfer probes

Table 2. Number of Sessions for Baseline, Self-Monitoring (SM) and Feedback, Goal-Setting and Reinforcement (FB/GS/R+) for Each Subject.

Self-Monitoring Posture Subjects

Subject	Baseline	SM	FB/GS/R+
SP 1	16	13	19
SP 2	20	10	15
SP 3	25	10	15

Self-Monitoring Hand-Wrist Group

Subject	Baseline	SM	FB/GS/R+
SH 1	16	13	13
SH 2	20	11	17
SH 3	25	10	13

Table 3. Discrimination Training Results: Percentage of Correct Discriminations of Posture Components and Hand-Wrist Positions for Each Subject.

	Percent Correct	
Subject	Posture	Hand-Wrist
SP 1	100	100
SP 2	90	90
SP 3	100	100
SH 1	90	90
SH 2	100	100
SH 3	100	100

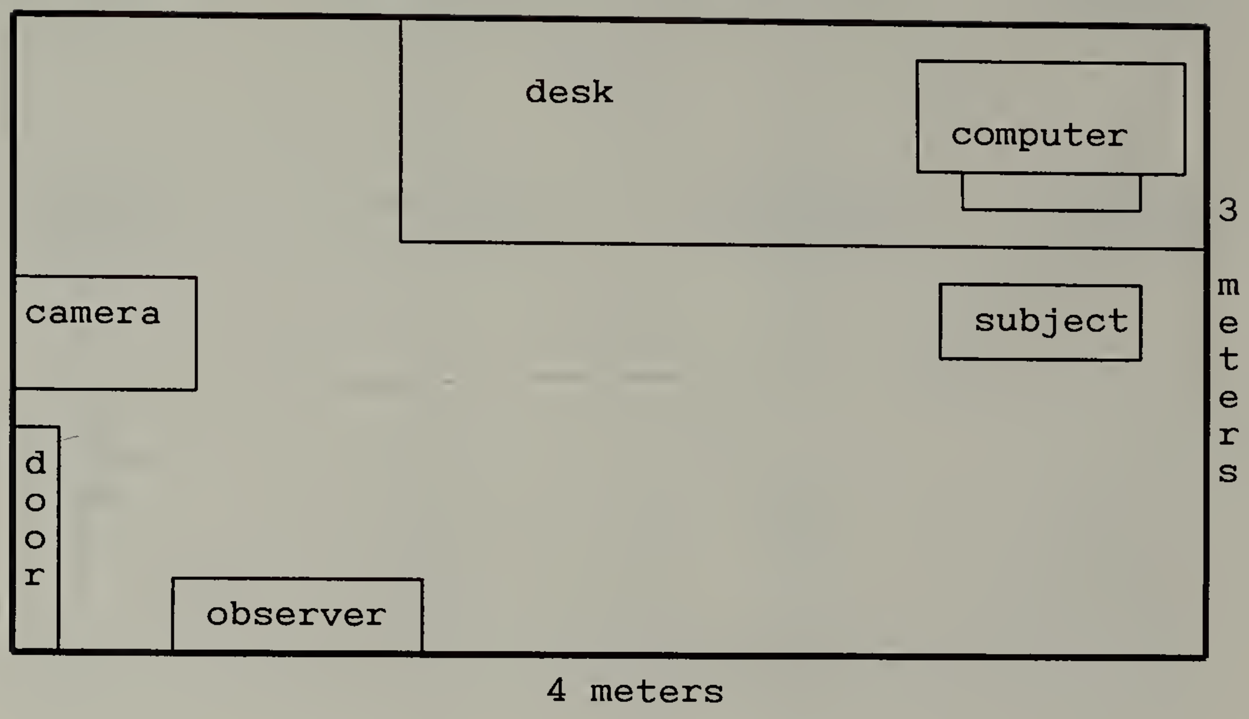
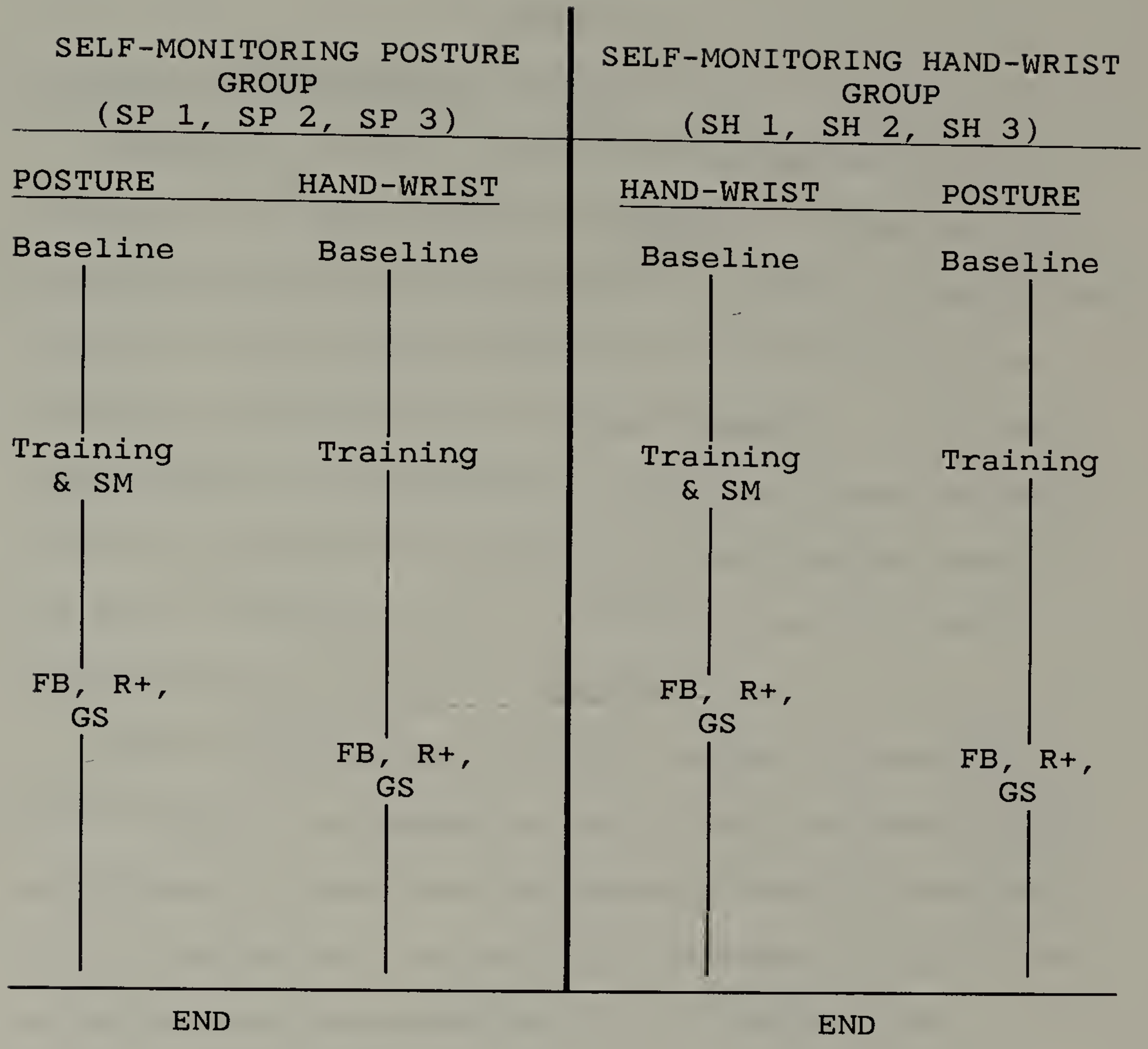


Figure 1: Diagram of Experimental Setting Including Location of Video Camera, Subject and Observer.



KEY: SM Self-Monitoring
FB Feedback
R+ Reinforcement
GS Goal-Setting

Figure 2: Flow Diagram of the Sequence of Procedures for Each Subject Group for Posture and Hand-Wrist Behaviors.

CHAPTER 3

RESULTS

Self-Monitoring Posture Subjects

Posture. Figure 3 presents the percentage of intervals for which posture items were scored as performed correctly per session for each subject during baseline, SM and SM/FB/GS/R+ (self-monitoring plus feedback, goal setting and reinforcement). The mean percentages of intervals for which each behavior was scored as performed correctly by each subject during baseline, Training & SM, SM/FB/GS/R+ and the last 5 sessions are provided in Table 4.

When training was provided and SM introduced immediately after baseline and a rapid increase in the percentage of behaviors performed correctly resulted for all subjects. All subjects attained a high level of performance and maintained it throughout the duration of the study. Subject SP 3 achieved the highest level of stability during SM (100%) followed by SP 2 and then by SP 3, with 99.3% and 99.1% respectively.

Feedback, goal setting and reinforcement on posture were added to the self-monitoring in SM/FB/GS/R+. Essentially, no further improvement was possible because near perfect performance had already been achieved with SM alone. Goal lines are not included because all subjects selected 100% maintenance levels. This reflected the level of performance during SM alone and performance data and goal levels overlap in SM/FB/GS/R+. Nor could posture performance data, at ceiling, be further positively impacted by the introduction of feedback, goal setting and reinforcement on hand-wrist positions (indicated by the arrow) Its introduction did not affect posture performance adversely.

Performance in the laboratory setting was found to improve correspondingly in the natural work setting for all subjects. Asterisks indicate in-office transfer probes in Figure 3. By the end of intervention, the mean percentage for the last five sessions ranged from 99.2% to 100% (see Table 4).

Hand-Wrist Position. Figure 4 displays the percentage of intervals during which subjects' hand-wrist positions were scored as being at neutral per session for Training and FB/GS/R+. The hand-wrist data were more variable than posture data for throughout the study. The mean percentages of intervals of each behavior performed correctly by each subject during baseline, training, FB/GS/R+ and the last 5 sessions are provided in Table 4.

Training was introduced immediately after baseline on hand-wrist behaviors: hand-wrist positions were not self-monitored. Following training hand-wrist positions increasingly were at neutral for all subjects. Subject SP 2 showed the greatest improvement over baseline. Her data were closely followed by that of SP 3 and SP 1. The pattern of hand-wrist data did not appear to be affected during the brief time when SM/FB/GS/R+ were being provided for posture (indicated by the arrows on Figure 4). The last 3 data points in Training for SP 2 showed an increasing trend but all points were within the range of previous performance.

After feedback, goal setting and reinforcement (FB/GS/R+) for hand-wrist performance were introduced performance improved further for all subjects. Subject selected goal levels are displayed as horizontal dashed lines (see Figure 4). Subject SP 3 achieved the highest level of stability (98.5%) followed by SP 2 and SP 1, with 97.5% and 93.8% respectively. By the end of intervention, the mean percentage for the last five sessions ranged from 99% to 100%.

All subjects' performance in the laboratory was duplicated in the natural work setting. Asterisks indicate probe data in Figure 4.

Accuracy of Self-Monitoring. Figure 5 contrasts subjects' self-monitored posture data graphed along with experimental data collected in the lab. Table 5 displays the mean percentages of both self-monitored and experimental data for each intervention. All subjects scored their performance highly accurately in all conditions. Subject SP 3 (who achieved near perfection) was the most accurate: self-monitored data overlapped perfectly with experimental data for all sessions. Subjects SP 1 and SP 2 provided data nearly as close to experimental data as SP 3, with differences between experimental and self-monitoring data of 1.9% and .9% respectively. Self-monitoring alone shows near perfect accuracy for all subjects and a slight improvement in accuracy was seen as a contiguous with FB/GS/R+ for SP 1 and SP 2 (see Table 5).

Self-Monitoring Hand-Wrist Subjects.

Hand-Wrist Position. Figure 6 displays the percentage of intervals subjects' hand-wrist positions were scored as neutral per session. Hand-wrist data were more variable than posture data throughout the study (see Figures 6 and 7). The mean percentages of each interval scored as performed correctly for each subject during baseline, training and SM, SM/FB/GS/R+ and the last 5 sessions are provided in Table 4.

Following training and after SM had been put in effect the percentage of intervals during which hand-wrist positions were at neutral increased for all subjects. Subjects SH 1 and SH 2 showed a clear improvement during SM. The mean percentage of intervals hand-wrist positions were at neutral for these subjects during baseline was; SH 1, .6% and SH 2, .3%. These means rose to 7.3% and 12.3% respectively during SM. Subject SH 3 also showed improved performance, going from 45.5% in baseline to 62.5%.

When feedback, goal setting and reinforcement for hand-wrist positions were added to the self-monitoring in SM/FB/GS/R+ performance accelerated sharply. There was a change in both level and trend (slope) for all subjects during SM/FB/GS/R+: the level increased and the slope of the data became steeper. Subject SH 3 attained the highest level of stability during the final intervention, with a mean of 80%, followed by SH 2 and SH 1, with 40% and 45.9% respectively. The mean percentage for the last five sessions ranged from 48% to 82%.

Improved performance corresponding to that of the laboratory setting was found in the natural work setting for all subjects. Asterisks indicate probe data in Figure 7.

<u>Posture</u>. Figure 7 presents the percentage of posture items performed correctly per session during baseline, following training and during FB/GS/R+. The mean percentages of intervals scored as performed correctly by each subject during baseline, Training, FB/GS/R+ and the last 5 sessions are provided in Table 4.

Training was introduced immediately after baseline on posture: posture was not self-monitored. Training increased the percentage of intervals for which posture behaviors were scored as performed correctly for all subjects. All attained a high level of performance and maintained it throughout the duration of the study. Subjects SH 3 and SH 4 achieved the highest levels of stability following training (100%) followed closely by SP 1, with 99.1%. During the brief time during which SM/FB/GS/R+ were provided for hand-wrist positions (indicated by the arrows on Figure 4) the pattern of posture data stabilized at 100%.

When feedback, goal setting and reinforcement (FB/GS/R+) on posture were introduced the data remained at 100%. Near perfect performance had already been established following training and this trend continued. Goal lines are not included because all subjects elected to maintain (at 100%). The pattern of data was not substantially affected: near perfect performance was already attained during Phase I and this continued. By the end of intervention, the mean percentage for the last five sessions was 100% for all subjects.

Performance in the laboratory was duplicated in the natural work setting by all subjects. Asterisks indicate in-office probes in Figure 7.

Accuracy of Self-Monitoring. Figure 8 contrasts the graphic representations of subjects' self-monitored hand-wrist position data versus that of the experimental data collected in the lab. Table 5 displays the mean percentages of both self-monitored and experimental data for each phase. During SM alone, all subjects scored their performance above that of the experimental data. Subject SH 3 displayed the least discrepancy from experimental data (11%), followed by SH 2 and SH 3, with differences of 53.2% and 57.7% respectively. The addition of FB/GS/R+ to SM provided feedback on accuracy and appeared to result in improved correspondence between the subject and experimenter for subjects SH 1 and SH 2, while SH 3 showed a slight decrease in correspondence (see Table 5), as she scored herself more conservatively than during previous sessions.

Data Entry Rates

Keystroke rate per minute (KPM) and words per minute (WPM) for sessions in baseline, training/self-monitoring and SM/FB/GS/R+ are displayed for SMP subjects (see Figure 9) and SMHW subjects (see Figure 10). Table 6 provides the mean KPM and WPM for each subject for each phase.

Both WPM and KPM appeared to remain extremely stable for all subjects throughout the entire study. Slight variations in the gross measure of KPM are seen for all subjects but WPM shows very little variance within subjects.

Consumer Satisfaction Data

All subjects had extremely similar reactions to their participation in the study. The mean scores and ranges are provided beside each item on the survey in Appendix F. No one reported the videotaping and live observations to be aversive. All indicated that the posture and hand-wrist positions learned were more comfortable than those they engaged in prior to the study. As a direct result of their participation, 4 of 6 subjects requested new office equipment to help them maintain the learned behaviors. One subject said "I believe that my hands and wrists have become stronger - I don't get any pain when I type for a long time like I used to." There were indications that subjects attempted to implement some of their training in other areas of their lives, such as different hand positions while doing needlework and crafts, and improved posture while sitting at home. In conclusion, all subjects were extremely pleased with the overall experience and expressed hope that they continue to engage in safe working behaviors. Three individuals concluded the survey with "I actually look forward to [RA's name] checking up on me!"

Table 4. Mean Percentage of Posture Components (Pos) and Hand-Wrist Positions (H-W) Performed Correctly During Baseline, Training/Self-Monitoring (T/SM), Feedback/Goal-Setting/Reinforcement (FB/GS/R+) and the Last 5 Sessions of Intervention.

Self-Monitoring Posture Subjects

Subject	Behavior	Baseline	T/SM	FB/GS/R+	Last 5
SP 1	Pos	74.0	99.1	99.8	100.0
	H-W	28.4	61.3	93.8	99.0
SP 2	Pos	79.9	99.3	99.5	99.2
	H-W	54.0	89.9	97.5	99.0
SP 3	Pos	86.4	100.0	100.0	100.0
	H-W	40.8	76.5	98.5	100.0

Self-Monitoring Hand-Wrist Subjects

Subject	Behavior	Baseline	T/SM	FB/GS/R+	Last 5
SH 1	Pos	83.5	99.1	100.0	100.0
	H-W	.6	7.3	40.0	48.0
SH 2	Pos	82.6	100.0	100.0	100.0
	H-W	.3	12.3	45.9	58.0
SH 3	Pos	90.8	100.0	100.0	100.0
	H-W	45.4	62.5	80.0	82.0

Table 5. Accuracy: Mean Percentage of Behaviors Performed Correctly of Self-Monitored Data Compared to Experimental Data for Self-Monitoring Alone (SM) and Self-Monitoring/Feedback/Goal-Setting/Reinforcement (SM/FB/GS/R+). The Difference Between Experimental and Self-Monitored Data is Shown: Subject Tendencies to Overestimate (+) and Underestimate (-) are Indicated.

EX = Experimental Data
SM = Self-Monitoring Data

Self-Monitoring Posture Subjects

Subject		SM	Difference		SM/FB/GS/R+	Difference
SP 1	EX	99.1	- 1.9	EX	99.8	-1.2
	SM	97.2		SM	98.6	
SP 2	EX	99.3	- .9	EX	99.5	+.1
	SM	98.4		SM	99.6	
SP 3	EX	100.0	0	EX	100.0	0
	SM	100.0		SM	100.0	

Self-Monitoring Hand-Wrist Subjects

Subject		SM	Difference		SM/FB/GS/R+	Difference
SH 1	EX	7.3	+57.7	EX	43.3	+15.5
	SM	65.0			58.8	
SH 2	EX	12.3	+53.2	EX	45.9	+ 6.7
	SM	65.5		SM	52.6	
SH 3	EX	62.5	+11.0	EX	80.0	-15.1
	SM	73.5		SM	64.9	

Table 6. Mean Keystroke Rate Per Minute (KPM) and Words Per Minute (WPM) for Each Subject for Baseline, Self-Monitoring (SM) and Self-Monitoring/Feedback/Goals-Setting/Reinforcement (SM/FB/GS/R+). Overall Mean Rates for SMP Subjects and SMHW Subjects.

Subject	Rate	Baseline	SM	SM/FB/GS/R+
Self-Monitoring Posture Subjects				
SP 1	KPM	225.9	231.7	258.6
	WPM	35.7	38.0	40.5
SP 2	KPM	325.3	332.5	324.1
	WPM	48.2	51.4	47.5
SP 3	KPM	193.1	198.3	188.7
	WPM	32.2	31.9	29.1
Overall Mean	KPM	248.1	284.1	257.1
	WPM	38.7	40.4	39.0
Self-Monitoring Hand-Wrist Subjects				
SH 1	KPM	365.8	374.7	338.7
	WPM	55.6	53.0	47.3
SH 2	KPM	364.9	358.3	337.7
	WPM	57.1	54.0	51.8
SH 3	KPM	306.2	339.8	321.2
	WPM	49.0	43.7	45.2
Overall Mean	KPM	339.6	357.6	332.5
	WPM	49.0	43.7	48.1

Figure 3. Posture Performance by Subjects Who Self-Monitored Posture: Percentage of Intervals During Which Posture Components Were Performed Correctly Per Session. Asterisks Indicate In-Office Probes by the Experimenter and Triangles Indicate Probes by the RA. Arrows Indicate the Start of Feedback on Hand-Wrist Positions.

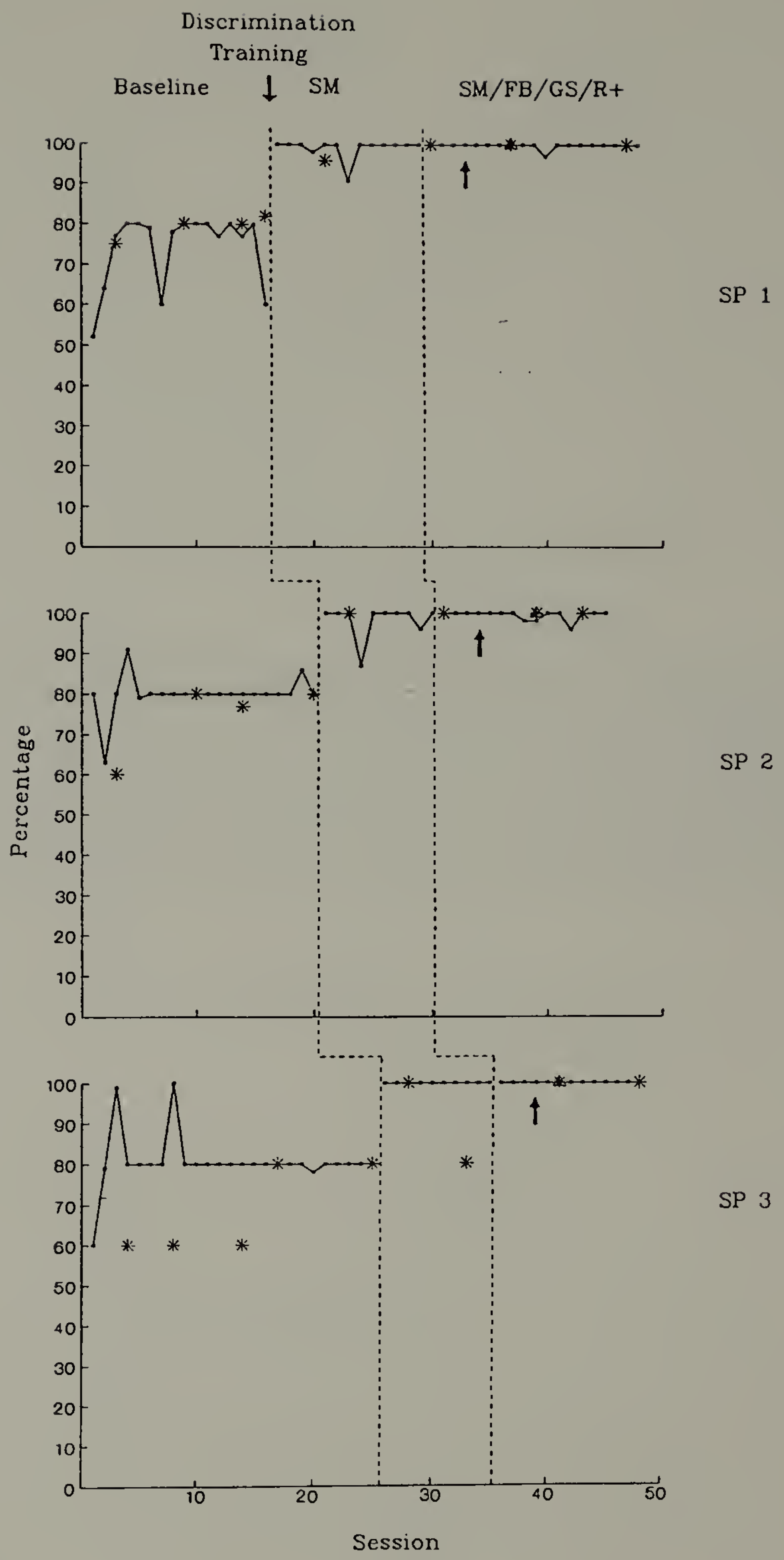

Discrimination Training
Baseline
SM
SM/FB/GS/R+
SP 1
SP 2
SP 3
Percentage
Session

Figure 4. Hand-Wrist Performance by Subjects Who Self-Monitored Posture: Percentage of Intervals Hand-Wrist Positions Were Recorded Each 10 Seconds at Neutral Per Session. Asterisks Indicate In-Office Probes by the Experimenter and Triangles Indicate Probes by the RA. Arrows Indicate the Start of Feedback on Posture. Horizontal Dashed Lines Indicate Goal Selections.

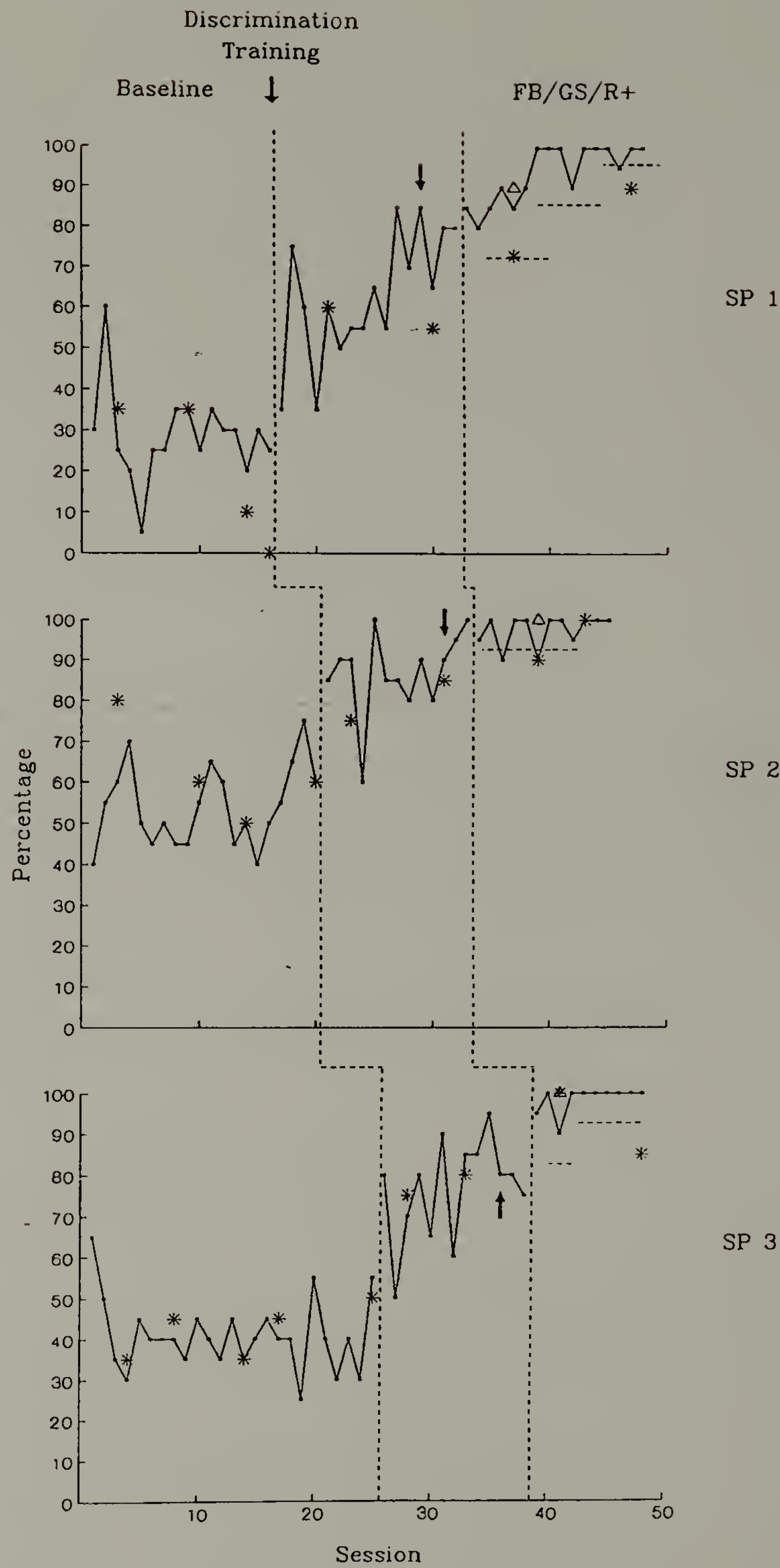

Discrimination
Training
Baseline
FB/GS/R+
SP 1
SP 2
SP 3
Percentage
Session
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50

Figure 5. Self-Monitoring Posture Subjects: Self-Monitored Posture Data Contrasted With Experimental Data.

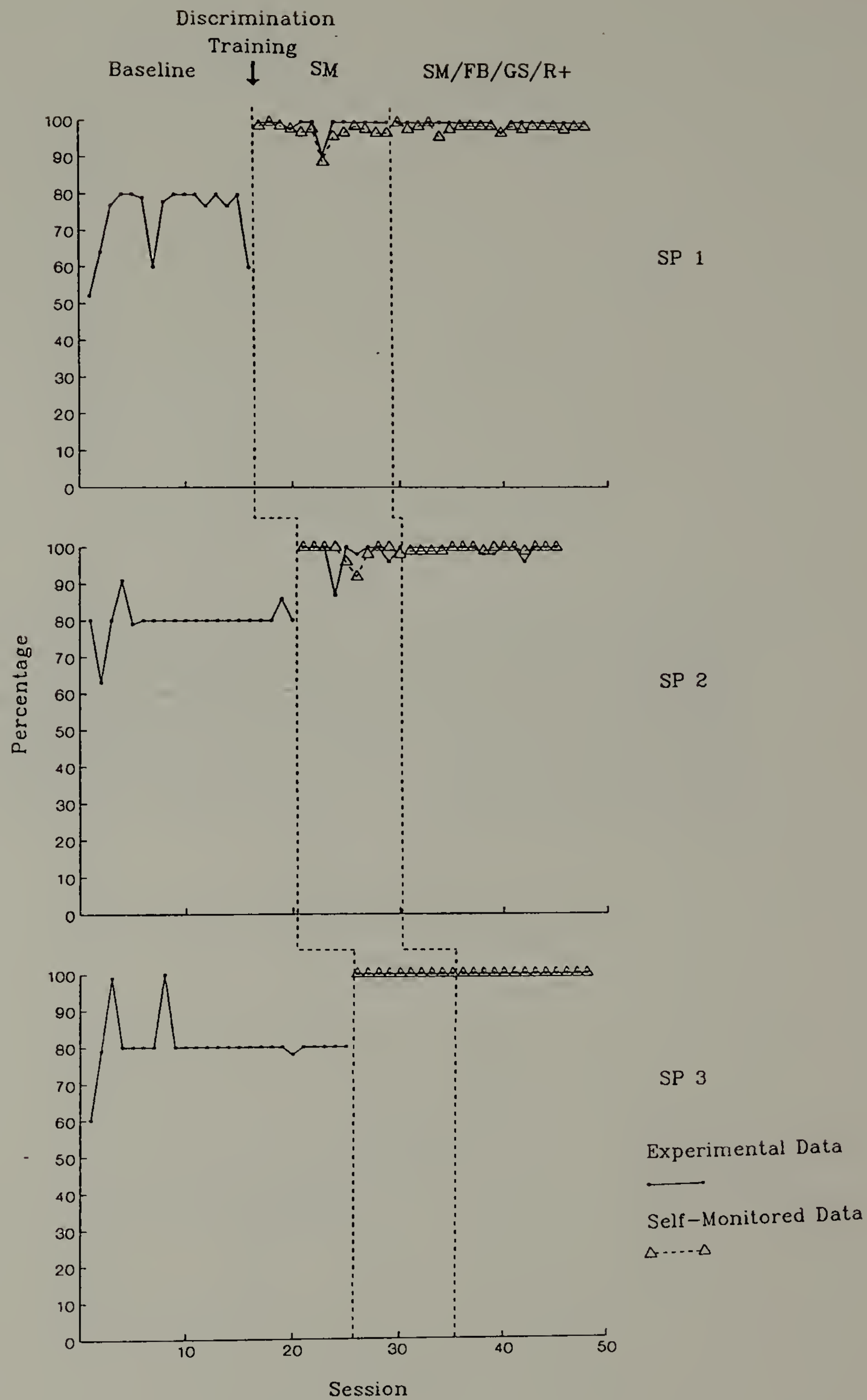

Discrimination Training
Baseline
SM
SM/FB/GS/R+
SP 1
SP 2
SP 3
Percentage
Session
Experimental Data
Self-Monitored Data
0
10
20
30
40
50
60
70
80
90
100

Figure 6. Hand-Wrist Performance by Subjects Who Self-Monitored Hand-Wrist Positions: Percentage of Intervals Hand-Wrist Positions Were Recorded Each 10 Seconds at Neutral Per Session. Asterisks Indicate In-Office Probes by the Experimenter and Triangles Indicate Probes by the RA. Arrows Indicate the Start of Feedback on Posture. Horizontal Dashed Lines Indicate Goal Selections.

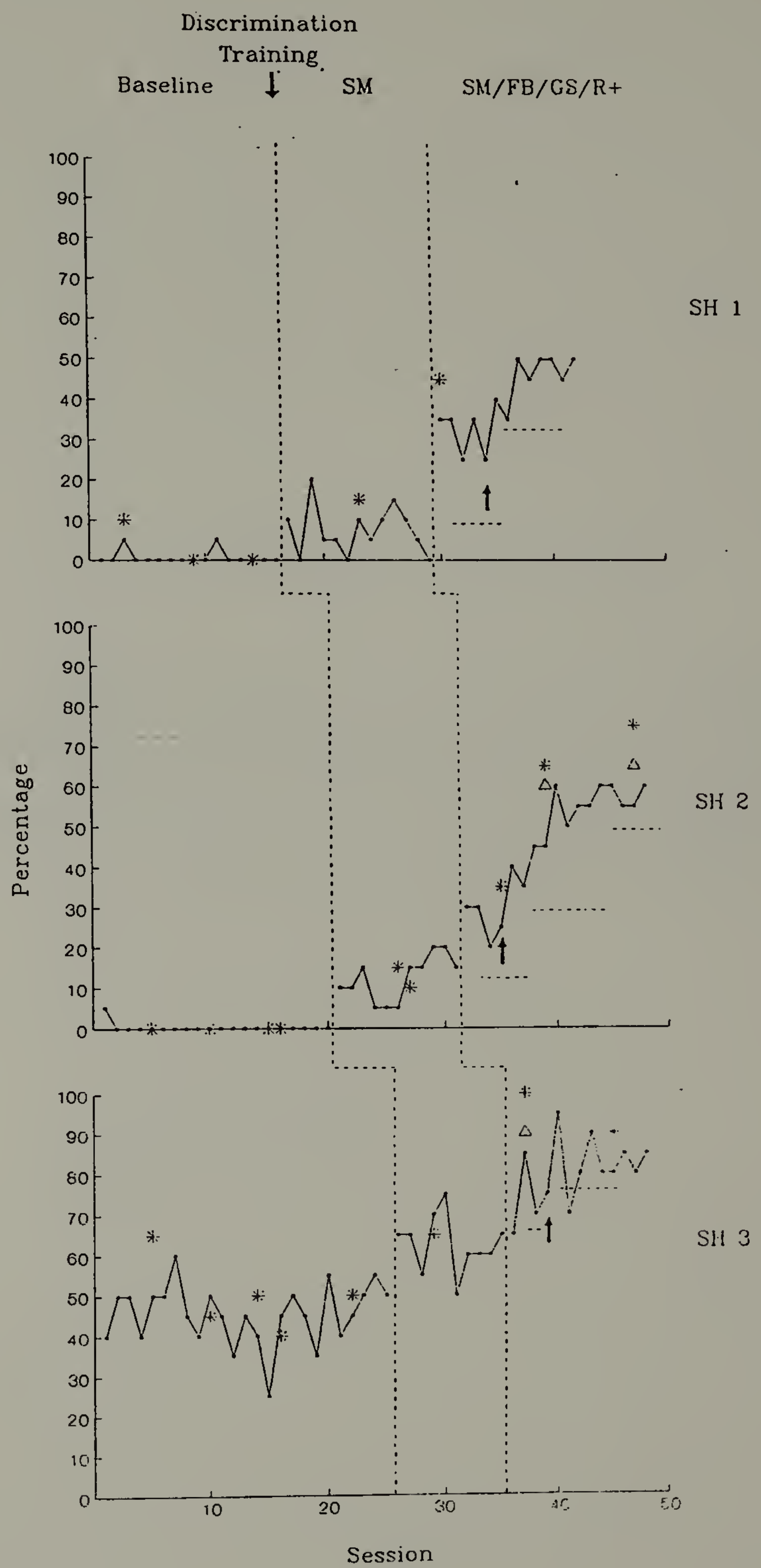
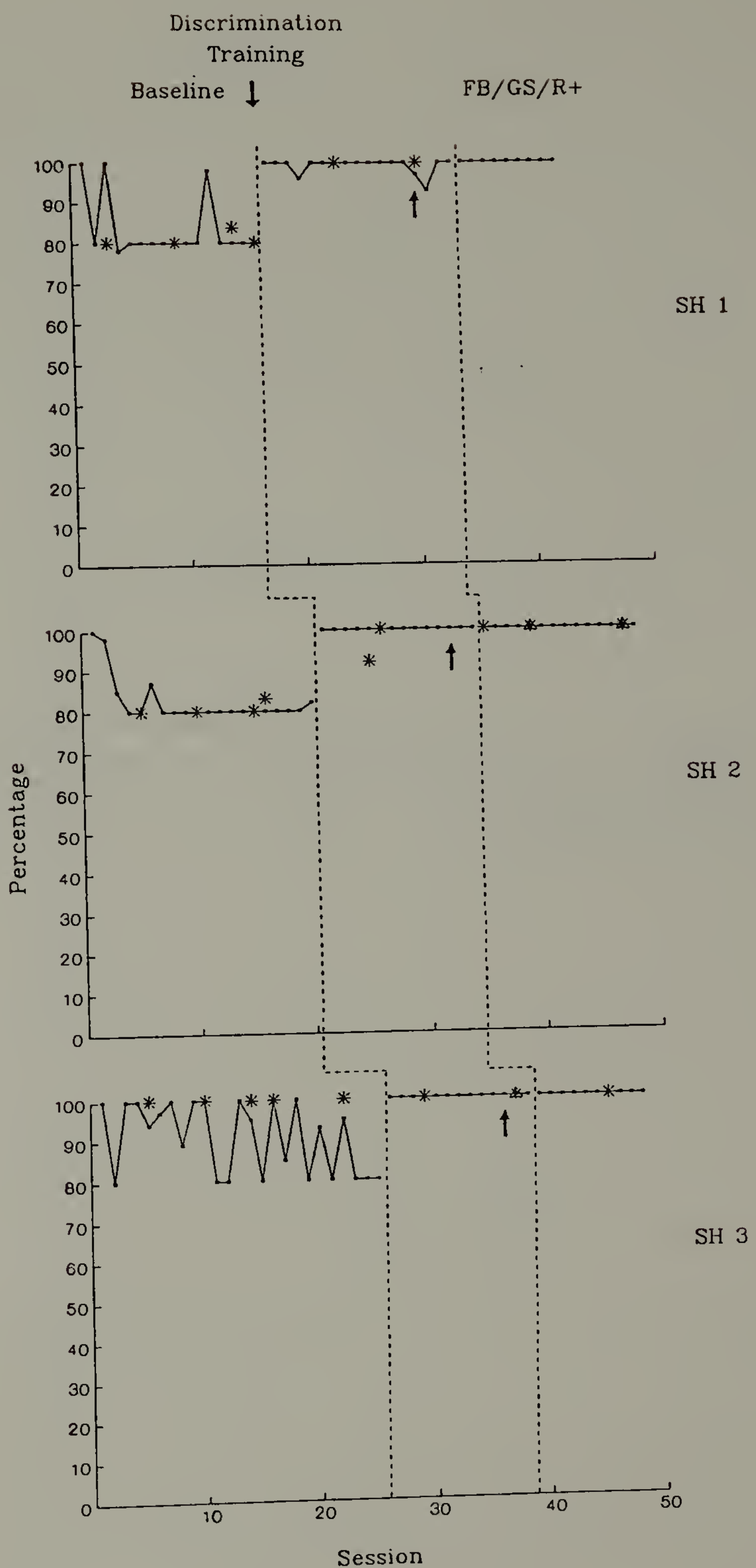

Discrimination
Training
Baseline
SM
SM/FB/GS/R+
SH 1
SH 2
SH 3
Percentage
Session
0
10
20
30
40
50
60
70
80
90
100

Figure 7. Posture Performance by Subjects Who Self-Monitored Hand-Wrist Positions: Percentage of Intervals During Which Posture Components Were Performed Correctly Per Session. Asterisks Indicate in-office Probes by the Experimenter and Triangles Indicate Probes by the RA. Arrows Indicate the Start of Feedback on Hand-Wrist Positions.



Discrimination
Training
Baseline
FB/GS/R+
SH 1
SH 2
SH 3
Percentage
Session
0
10
20
30
40
50
60
70
80
90
100

Figure 8. Self-Monitoring Hand Wrist Subjects: Self-Monitored Hand-Wrist Positions Data Contrasted With Experimental Data.

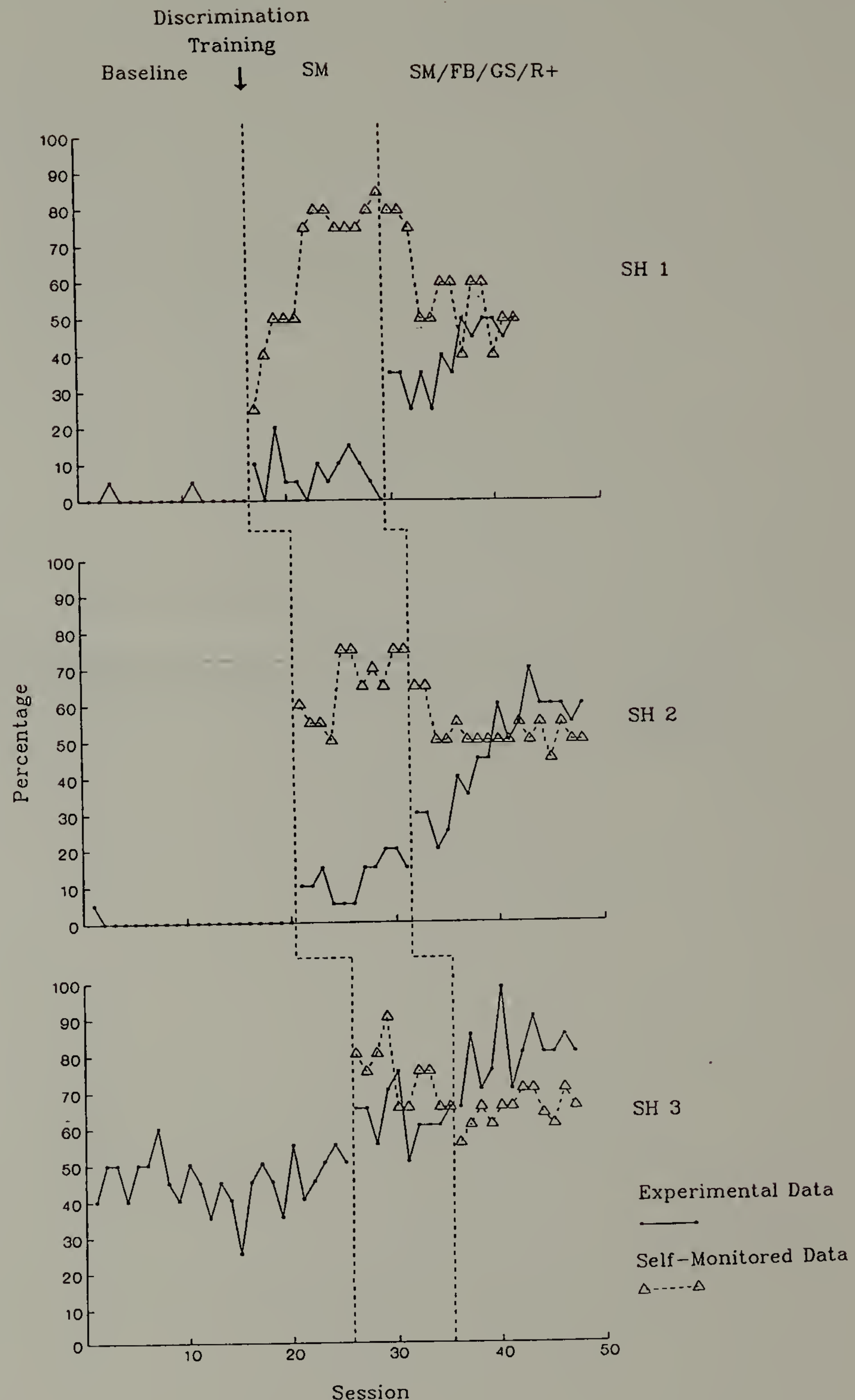

Discrimination
Training
Baseline
SM
SM/FB/GS/R+
SH 1
SH 2
SH 3
Percentage
Session
Experimental Data
Self-Monitored Data

Figure 9. Self-Monitoring Posture Subjects: Keystroke Rate Per Minute (KPM) and Words Per Minute (WPM) Per Session.

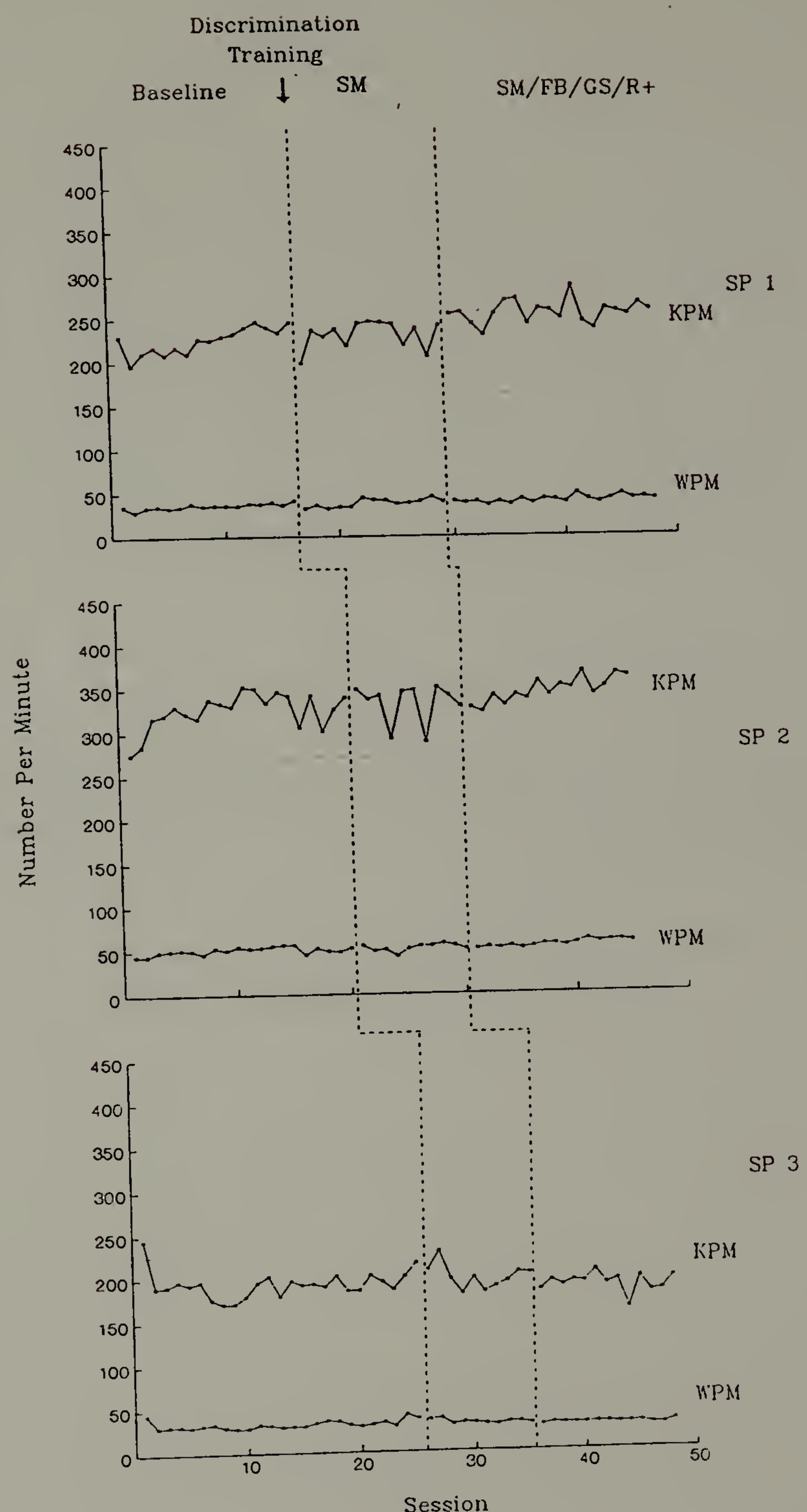
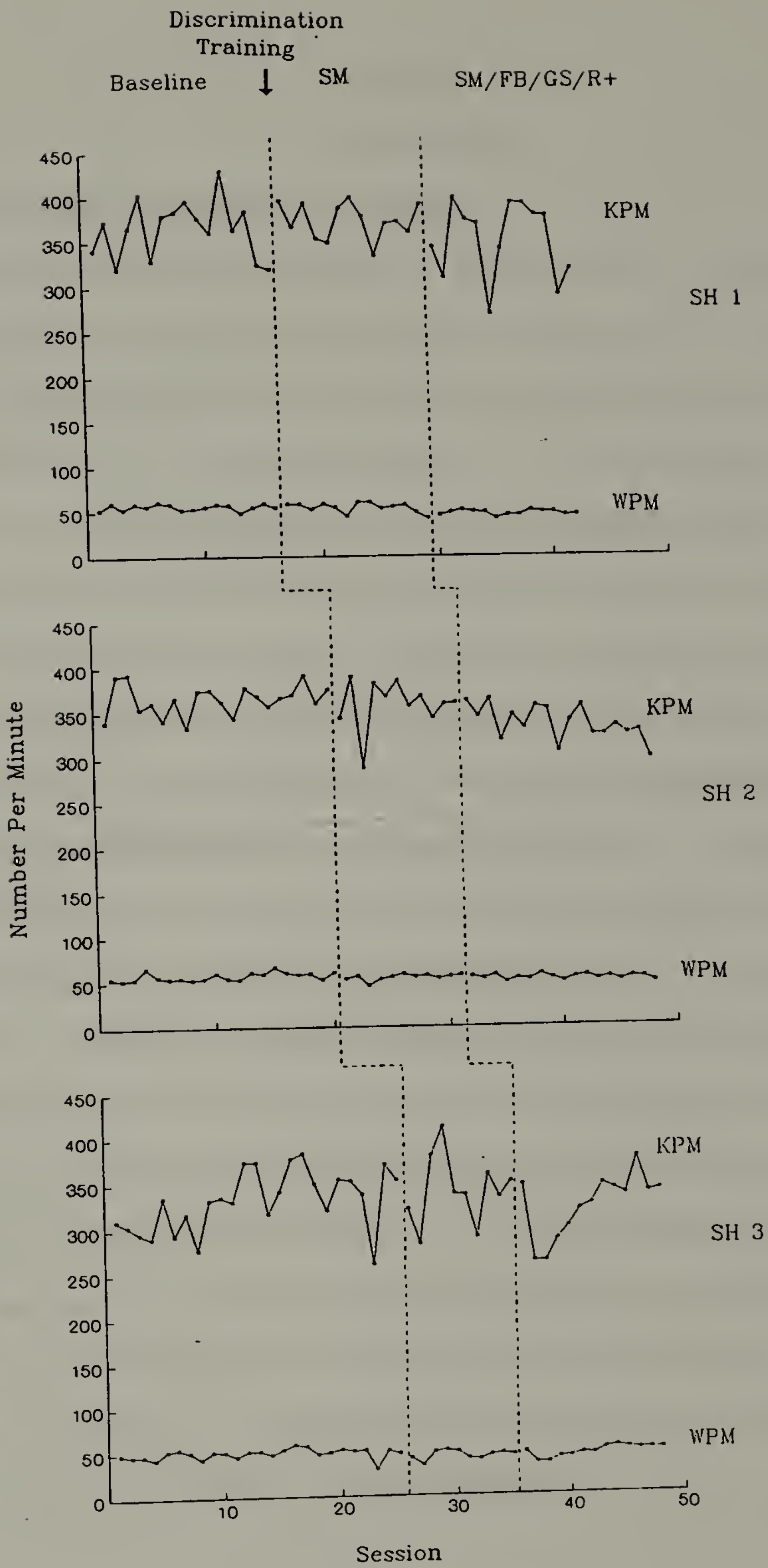

Discrimination Training
Baseline
SM
SM/FB/GS/R+
SP 1
KPM
WPM
SP 2
KPM
WPM
SP 3
KPM
WPM
Number Per Minute
Session
0
50
100
150
200
250
300
350
400
450
10
20
30
40
50

Figure 10. Self-Monitoring Hand-Wrist Subjects: Keystroke Rate Per Minute (KPM) and Words Per Minute (WPM) Per Session.


Discrimination Training
Baseline
SM
SM/FB/GS/R+
KPM
WPM
SH 1
SH 2
SH 3
Number Per Minute
Session
0
50
100
150
200
250
300
350
400
450
10
20
30
40
50

CHAPTER 4

DISCUSSION

Experimental Purpose and Goals

The current study had 4 main goals; the first 3 centered on laboratory based sessions and the fourth on work which is to continue after completion of the formal study. The goals were: 1) to apply and demonstrate the reliability of the basic system targeted at posture and hand-wrist positions developed during pilot work (Blake, 1991) to subjects who work at a keyboard in an applied setting; 2) to effect substantial improvements in the target behaviors through the systematic implementation of a package consisting of training, self-monitoring and intensive feedback/goal-setting/reinforcement; 3) to assess and promote transfer of the learned behaviors from the laboratory to the natural work environments of the subjects; 4) to demonstrate sustained maintenance of acquired skills over time. It was believed that realizing these goals would substantially impact on the risk of CTS inherent in keyboard entry tasks. The first three goals were met successfully, but continued maintenance remains to be assessed.

The above goals were addressed through an intensive empirical undertaking. The subsequent sections will be devoted to a discussion of the details of aspects of the methodology and current and future implications of the research.

Reliability. Consistently high indices of inter-observer-agreement revealed the observational system to be extremely reliable for the videotaped data. Observer training was reasonably brief and the calculated percentages of agreement between observers rapidly approached and hovered around the 100% mark for posture items. Components of posture consisted of easily discernable gross motor behaviors which no doubt accounts, at least partially, for the outstanding agreement scores obtained.

Indices of agreement for hand-wrist positions were slightly lower and more variable than those for posture. Although the task of scoring hand-wrist position was mastered rapidly, it required more close vigilance than did the posture scoring task. Posture items tended to be sustained for long durations (i.e., feet were flat on floor for entire session) while observations of hand-wrist positions required observers to scrutinize each and every movement in anticipation of the time sampling cue. In light of the rigorous observational system, the mean index of agreement of 90.6% on those items was considered more than satisfactory.

Unfortunately, assessment of reliability on data collected during in-office probes is fairly sparse, and thus, must be reviewed with caution. The experimenter (who also functioned as the primary observer) was responsible for the collection of probe data until nearly the end of the study. The layout of the natural work environment, subjects' offices, prohibited the use of the video camera, thereby necessitating *in vivo* observations. Scheduling conflicts between the experimenter, RA and subjects precluded simultaneous observations to assess reliability and it was not until the final phase that these conflicts were alleviated. Once side by side observations began to be collected, however, the indices of agreement were well within the range of those obtained for videotaped laboratory sessions.

True assessments of generalization were not possible due to the experimental design: a limited version of the intervention (feedback and reinforcement) was also used during probes conducted in subjects' offices. No types of interventions would have been used in pure generalization probes. Rather, a cross-setting replication was accomplished through the in-office probes and the data were used to determine the extent of transfer of skills from the laboratory to the work setting. Probe data indicated a substantial transfer of skills from the lab to the natural setting for all subjects and experimental conditions, but the true value of this transfer cannot be ascertained due to the sparse reliability assessments. Hopefully, maintenance data will reveal a continued level of optimal performance for the subjects. Should this occur, the author's confidence in the probe data will be strengthened, although reactivity will remain an issue. Maintenance probes will be gathered by the RA over the next several months and arrangements for reliability assessments on these probes have been made. Either the author or an additional trained RA will periodically conduct simultaneous observations with the RA in subjects' offices.

<u>Training and Self-Monitoring</u>. Following training and self-monitoring of one of the two classes of behavior, all subjects demonstrated an improvement over

baseline in the target behaviors. During training subjects received extensive information about CTS and what they could do to minimize their risk during keyboard entry tasks. In conjunction with this, each subject also received rigorous individual discrimination training on the target behaviors. Subjects were required to demonstrate at least an 80% mastery level during this training before proceeding with the next phase of the study. Kopp (1988), Thoreson and Mahoney (1974) and Watson & Tharp (1972) among others, all demonstrated that the magnitude and rate of change of self-monitored behaviors are positively correlated with the accuracy of discrimination. Thus, no further data were collected until this objective was achieved. Fortunately, all subjects mastered the skill within one session. Following completion of training, self-monitoring commenced.

Unfortunately, the experimental design did not allow the effects of training and self-monitoring to be separated and analyzed. Indeed, it did not allow the effect of any one aspect of intervention (training, SM or FB/GS/R+) to be examined in isolation. It is possible that training alone influenced the behavior in the observed ways. However, as previously stated, training alone has not been demonstrated effectively to change and maintain well established performance. Self-monitoring is an extremely powerful tool, and is likely to have impacted upon the behaviors discussed here. As an added benefit, SM may have added an element of subjects' "ownership" of the procedures, and might have increased their compliance (frequent comments and communications with the subjects support this idea).

The implementation of training and self-monitoring was paired with an increase in the percentage of correct posture components and the percentage of time hand-wrist positions were at neutral. The efficacy and power of self-monitoring has been demonstrated extensively in the clinical literature and seemed to be further supported by the current data (Kanfer & Schefft, 1988; Kopp, 1988; Thoreson & Mahoney, 1974). Previously, the author made several recommendations based on an extensive literature review concerning the most effective way to use self-monitoring in a non-clinical setting. Every attempt was made to adhere to these suggestions in the design of the current self-monitoring package, and it is believed that this accounts, at least in part, for much of the success demonstrated.

Numerous researchers have found that a high level of subject motivation will impact positively on the results of self-monitoring: both the magnitude and rate of behavioral change will increase (Belfiore, Mace & Browder, 1989; Thoreson & Mahoney, 1974; Watson & Tharp, 1972). Consequently, attempts were made to increase the motivational level of the subjects. During a secretarial staff meeting the author informed potential participants of the problems surrounding keyboard entry tasks and of the dangers of CTDs. Actual subjects were later culled from this group based upon their personal interest in the study and informal interviews. The experimenter stressed that subjects would learn to interact more safely with their work environment and that, hopefully, they would benefit from the experience. Additionally, that the monetary incentive probably played a role in motivational levels cannot be ignored. Although subjects did not self-select the self-monitored behaviors, they did initiate participation in the study.

Another recommendation was that subjects participate in goal setting. Participative goal setting has been demonstrated to be an extremely powerful behavioral change tool in both self-monitoring and in other applications (Balcazar, Hopkins & Suarez, 1986; Mace & Kratochwill, 1985; McNally, Kompik & Sherman, 1984; Sulzer-Azaroff & Mayer, 1991). Kanfer and Schefft (1988) have argued that the effects of self-monitoring are enhanced through participative goal setting because the subject's perceived control over the situation increases. In the present study, subjects self-selected goal levels and were coached by the experimenter when necessary. One subject commented with mild surprise "Oh - I get to pick the goal and put it on the graph? Great!" Clearly, this individual appreciated being included in the decision and it is believed that other subjects had similar feelings.

Feedback and reinforcement based on behavioral change is critical not only in self-monitoring, but has been shown to be an extremely powerful tool in the modification of safe behaviors. Sulzer-Azaroff and Blake-McCann (in press) provide numerous examples where feedback, reinforcement and goal setting have been successfully used to improve occupational safety. Subjects in the current study received extensive verbal praise and detailed feedback during the final portion of the intervention. The experimenter was careful to recognize and comment on any improvements the subject made, rather than dwell on the level of baseline data or the accuracy of self-monitored data. One subject was disappointed to see that the percentage of time her hand-wrist positions were at neutral was not nearly as high on the graph as her posture data were. The enormous improvement from a baseline rate of 0% was stressed to her, and when it was explained that her hand-wrist position had shown substantial improvement she seemed delighted and began to recognize the achievements she had made.

Finally, the mechanisms used to self-monitor were as obtrusive as reasonably feasible and clearly external monitoring was conducted by the experimenter. Self-recording occurred immediately following each session. The data sheet was placed directly next to the keyboard and the laminated card defining optimal biomechanics to be used was placed at eye level and beside the computer screen. Although it occurred rarely, if subjects rose from their chairs before providing self-monitored data, the experimenter reminded them, at which point they complied. The above recording features, or parameters, have been found significantly to enhance self-monitoring (Belfiore, Mace & Browder, 1989; Kanfer & Schefft, 1988; Kazdin, 1974; Watson & Tharp, 1972) and probably contributed to the success of the procedures employed here.

<u>Feedback, Goal-Setting and Reinforcement</u>. As anticipated, the introduction of feedback, goal-setting and reinforcement resulted in a further improvement in one of the target behaviors over the self-monitoring results: hand-wrist data were affected, however, posture data was not because it was already at ceiling when this was introduced. An improvement in the percentage of time hand-wrist positions were at neutral was demonstrated by all subjects. Due to the fact that all posture data reached the optimal level (100%) following training, no further improvement was possible: the 100% level continued for all subjects throughout the final phase. It was probably not necessary to introduce the FB/GS/R+ on posture to maintain the 100% levels of performance. It was implemented to maintain the consistency of all procedures for all subjects across all phases of the study.

The results of feedback are not surprising - it has been demonstrated to be an extremely effective behavioral change tool and has been used extensively to modify safety behaviors (see Sulzer-Azaroff & Blake-McCann, in press, for an extensive list). The current results support works which indicate that intensive feedback, participative goal-setting and reinforcement combine to form a powerful tool with many varied uses.

The effects of the feedback package were demonstrated only with hand-wrist positions since no additional improvements in posture were possible at the time it was introduced. Training plus self-monitoring of posture yielded the dramatic improvements over baseline. Indeed, even those subjects who did not self-monitor posture and only received training showed the same pattern as those subjects who received both training and self-monitoring. Similar effects of training alone have not been found to produce enduring modifications in well established detrimental habits. Alavosius and Sulzer-Azaroff (1990) found that instructional training of correct lifting techniques resulted in only short term improvements for a nursing staff who had regularly practiced sub-optimal techniques over the course of their performance on the job. In that case, long-term substantial improvements were seen when and only when an intensive feedback package was implemented. Instructions and educational packages in the absence of feedback and reinforcement contingencies "...are likely to lead to only very brief improvements in behavior" (O'Brien & Dickinson, 1982, p. 18). The training package used in the current study, however, also incorporated intensive discrimination training of the target behaviors. This may account for the effects training had on both posture and hand-wrist positions. However, there was still a training difference between posture and hand-wrist positions.

Although the feedback package was not essential for both behaviors in the present study, the author has not dismissed its utility. It is likely that sustained maintenance of the behaviors in the natural setting may well require additional external support. The author is prepared to reintroduce self-monitoring, feedback and other aspects of the interventions to aid in prolonged maintenance.

The discrepancy between the effect training had on posture and hand-wrist positions may be due to several factors. One possibility in the nature of the response. Primarily, posture components consisted of mainly static gross motor behaviors which tended to be either absent or present for the entire session. For example, if a subject had the correct foot position at the beginning of the session she usually maintained it for the entire session. Hand-wrist positions, however, were much more dynamic. Typists move many parts of their hands and arms during the task and perhaps it was more difficult for subjects to discriminate correct hand-wrist positions than correct posture components. McFall (1977) indicates that gross motor behaviors with external environmental cues are more salient, and therefore easier to discriminate, than other behaviors.

Second, several external factors present may have served as discriminative stimuli which occasioned correct posture but which were neutral to hand-wrist positions. A small footstool was present, which several subjects began using to achieve the correct foot position following training. The chair could be adjusted to alter height, seat pitch and back pitch to aid the assumption of correct posture. Although subjects were aware that the chair could be adjusted, they did so rarely during baseline. Following training, however, all subjects routinely adjusted the chair to the position which aided in their achievement of correct posture. Verbeek (1991) found similar results: office workers were more likely to adjust the workstation following than prior to training. Another stimulus was the laminated card. Although it spelled out both target behaviors, it provided an illustration of the correct posture components only; no illustration of hand-wrist positions was provided. All of the above very likely served as discriminative cues for correct posture. Hand-wrist positions contained no such cues.

Finally, the rapidity of change of posture compared to hand-wrist positions deserves comment. The behavior changed quite rapidly to the optimal level (within several sessions for all subjects) and sustained at this level both in the laboratory and the office setting for the remainder of the study. Pilot research also found that posture components changed more rapidly and stabilized at an optimal level far earlier than hand-wrist positions. It is not known whether this pattern of change would be replicated in another population. A useful line of research might explore individual differences in the modification of posture. For example, age, occupation, learning history (i.e., an individual with dance training may be very different from someone else) and physiological makeup may all influence postural components. The subjects here had close to an ideal situation in which to adopt a new posture, and this may have greatly added to the success of the program.

An additional result of the feedback component was that accuracy of self-monitored data greatly improved. Apparently, in this case inaccurate self-monitoring produced no deleterious effect. Perhaps the performance would have been influenced differently had accuracy been better, however, such conclusions cannot be reached with the current data. Results support the assumption that self-monitoring does not necessarily need to be accurate to promote desired behavioral change; in this case when subjects were provided with the presumably more objective and valid experimental data both the magnitude and rate of change did increase along with improved correspondence between the subject and experimenter (Baskett, 1985; Hayes & Nelson, 1983; Willis & Nelson, 1982). It is impossible to determine whether this was an effect of the self-monitoring alone, or a combination of all of the experimental elements.

Implications for Research on CTDs

Although the subjects were representative of a population at risk for CTDs, especially carpal tunnel syndrome, no valid assessments of risk reduction can be made. True measurements of risk reduction would require a longitudinal study with control and treatment groups to objectively assess the impact the intervention has on subject risk. Research such as this could possibly provide the necessary causal data linking detrimental posture and hand-wrist positions to work-related upper limb disorders. This would support the strong correlational evidence which currently links the behaviors to such disorders (Armstrong et al., 1987; Kroemer, 1989; Rose, 1991; Silverstein, Fine & Armstrong, 1987).

Jay (1991) calls for extensive training of workers in the use of their workstation once optimal ergonomic and task design have been completed. "It would be pointless to spend money on ergonomically designed workstations and then neglect to train employees in how to use it." (Jay, 1991, p. 23); however, all too often this is exactly the case. Working postures have been directly related to the workstation (Green, Griggs & Wrigley, 1991) and effective adjustments of the equipment is often required before correct posture can be assumed. The current study addressed the training issues raised by Jay (1991): 1) training in the adjustment of the workstation equipment was provided and the most adjustable workstation was aimed for; 2) subjects were informed about risks inherent in keyboard entry tasks and what they could do to protect themselves; 3) self-help measures were adopted and intensive monitoring of posture and hand-wrist positions taken.

In addition to ergonomics, task design and training, the overall culture or "climate" of the organization is a key factor in the success of any safety program (Hale, Gerlings, Swueste & Heimplaetzer, 1991; Harshbarger & Rose, 1991; Jay, 1991). The current study had a high level of support and enthusiasm throughout all levels of the organization. The department head and the secretarial staff manager were approached with the concept of the project prior to the recruitment of subjects. Their enthusiasm and support made it possible. Indeed, the results of the project and subject satisfaction resulted in some related permanent changes within the department. Several new chairs were ordered and employees received training on the optimal use of their workstations. Footstools were manufactured and distributed for those individuals who required them. The secretarial manager reported that even individuals who were not directly involved in the study approached her asking for workstation evaluation and, if necessary, redesign. Clearly, the corporate climate has supported comprehensive approaches to workplace safety and has taken measures to continue progress in the future. The author had hoped for such results, but is quite pleased with the extent of the reaction.

The link between ergonomics and behavioral change (Blair & Bear-Lehman, 1987) has been strengthened. Current data provide evidence that behaviors highly associated with CTDs can be measured objectively and reliably. In addition, the topography of these behaviors can be changed to adhere to the recommended biomechanical guidelines discussed earlier in the paper. Not only is the training package highly effective, but, as demonstrated here, it is also feasible in an applied setting.

Self-monitoring and a feedback package are fairly easy to integrate in a work setting. The literature has numerous examples of behavioral packages implemented in applied settings which resulted in improved occupational safety (e.g., Alavosius & Sulzer-Azaroff, 1990; Naesaenan & Saari, 1990; Reber, Wallin &

Chhokar, 1984; Sulzer-Azaroff, Loafman, Merante & Hlavacek, 1990). A feedback and reinforcement package is fairly simple to apply, and the current study suggests that even highly simplified self-monitoring might be an effective adjunct to training in performance change system like the present one. This method was cost effective and did not require extensive time or training. Subjects were trained to discriminate the target behaviors and self-monitor them within one session.

Methodological Issues

External Validity. Cambell and Stanley (1963) define external validity as the degree to which the results gained from an empirical system may be applied to other measurement and treatment variables, settings and groups. There are several threats to external validity, and when one or more are operating, the generality of the research is severely limited. A threat of concern in the current study was reactivity.

"One source of error associated with most assessment instruments, but of particular relevance to behavioral observation, is reactivity--the phenomenon in which an assessment procedure results in modification of the behavior of subjects being assessed." (Haynes & Horn, 1982, p. 369-370) Based on an extensive review of the literature, Haynes and Horn (1982, pp. 381-382) offer the following recommendations to minimize reactive effects:

a) use of participant observers or other alternative and supplementary measures

b) use of covert observation

c) minimization of the obtrusiveness of the observers and observation process

d) use of telemetry, video-camera, or tape recorders

e) minimization of subject-observer interaction and other discriminative properties of the observers

f) instructions to subjects to "act natural"

g) allowing sufficient time for dissipation of reactive slope and variability in observation data

h) use of a number of observers or observation procedures so that differential effects cancel out.

Two sources of reactivity need to be considered separately in the current experiment: experimental observations and self-observations by the subjects.

In light of the self-monitoring literature, reactivity was no only a natural factor in the experimental observations but was intentionally capitalized upon during self-monitoring. Although a video-camera was used to record each session and time sample laboratory data were not calculated *in vivo*, the experimenter was present throughout the entire session and the camera was highly salient. Reactivity was probably even greater during in-office probes because live observations were conducted in close proximity to the subjects and at times there were two observers present (experimenter and RA). This final scenario resulted in extremely cramped quarters in several subjects' offices. Although all subjects reported that the close proximity of the experimenter during sessions and the video-camera were ignored after a couple of sessions, it is unlikely that reactivity was eliminated completely. As a result, determining the nature of the target behaviors in the absence of the observation instruments is not feasible.

The extensive stable baseline data that were taken to provide a measure against which the effectiveness of the interventions could be assessed. Reactivity was a factor throughout the entire study. Even though it might have been the highest at the beginning of the study, it probably leveled off and either maintained a constant effect or dissipated during the remainder of the sessions. It is very unlikely that reactivity got worse as time went by.

The second source of reactivity is inherent in the self-monitoring procedure (Kanfer, 1970; 1971; 1977; Rachlin, 1974; Thoreson & Mahoney, 1974). Participants in self-monitoring programs are responsible for two important roles: subject and observer. It is impossible for an individual to simultaneously ignore herself (in the role of subject) while attending to herself (in the role of observer). The reactive effects arising from self-monitoring, therefore, make it impossible to separate out any distinct effects of the self-monitoring procedure in general. Reactivity actually drives the entire process and is largely responsible for its success. [See Rachlin (1974), Kanfer (1970; 1971; 1975; 1977) and Nelson & Hayes (1981) for three basic models which account for the high level of reactivity inherent in self-monitoring.]

Limitations to Generality

Because all subjects worked in the same building in which the laboratory was housed and all typed as part of normal job requirements, in-office probe data were gathered relatively easily. Probes were taken throughout all phases of the study and roughly 20% of all sessions were paired with in-office probes: a single probe was taken for every 5 experimental sessions for each subject (roughly, one probe per week). As previously discussed, a major problem with the probes centered on the issue of reliability. The probe data need to be interpreted with caution due to this methodological shortcoming. Ideally, extensive inter-observer reliability data on the probes would have been gathered with the same diligence as the data gathered in the laboratory. As stated before, unfortunate limitations beyond the experimenter's control interfered and only the final probes were checked for reliability. Although data indicate that the learned behaviors (improved posture and hand-wrist positions) transferred from the laboratory to the normal work environment, several factors need to be considered.

In addition to the lack of acceptable assessments of reliability, the power of probe data may have been weakened because the study was conducted during the summer months. This is significant when subjects carry a lighter work load than during academic semesters. "Summer hours" are scheduled and the work day is shorter: some subjects worked only a four day week instead of the normal five. The work load was also considerably lighter - one subject reported that she engaged in keyboard tasks roughly one-half of the amount of time during the summer as during the remainder of the year. It is hoped that maintenance data will indicate a sustained performance of the learned behaviors under "normal" working conditions.

Maintenance

The RA employed during the course of the study will continue to collect maintenance data, presumably it is for at least a year. Probes will be unannounced and occur twice each month for each subject. Periodically, the experimenter and/or a second trained RA will conduct dual observations as a basis for assessing reliability data.

As with virtually all behavioral research, the issue of maintenance is a vital one for self-monitoring programs. Two subjects reported that they intended to continue some form of self-monitoring, but it has not been formally programmed into the maintenance phase. Unfortunately, unless overtly supported, many programs tend to diminish and maintenance tends not to be long lived. Many self-monitoring programs maintain presumably due to high levels of subject self-reinforcement (Belfiore, Mace & Browder, 1989; Kopp, 1988; McNally, Kompik & Sherman, 1984). Maintenance of most self-monitoring programs is enhanced, however, when reinforcement is delivered from an external source (Ackerman & Shapiro, 1984; Belfiore, Mace & Browder, 1989; Mace & Kratochwill, 1985; Rachlin, 1978). There are no formal reinforcement systems aimed at the target behaviors operating in the present organization at this time. Reinforcement is delivered informally among the participants of the program. On one occasion, the author overheard two subjects in adjacent offices discussing the advantages of better posture and hand-wrist positions, and that they would "check up on each other" once the experimenter left the university. This informal peer monitoring, should it occur, combined with self-reinforcement on the learned behaviors may yield promising maintenance data.

If adequate maintenance is not demonstrated by this subject population, the author plans to return to the organization and set up additional support systems for the behaviors. Structured feedback and reinforcement from both peers and management will be attempted.

Future Directions

The implications of this research are far reaching. Of primary concern is the need to demonstrate a causal link between the target behaviors and subsequent risk of CTS. Assuming this link has been established firmly, intensive training programs similar to the one examined here could be paired with other ergonomic adjustments, such as job rotation, exercise programs, increased breaks from work tasks and so on, and implemented on a wide scale basis in industry.

Improved Generalization. One of the main goals was to demonstrate specific behavioral change in a population who daily engage in keyboard entry tasks and to demonstrate generalization to the natural work environment. This goal was only partially accomplished. The physical layout of the subjects' offices and numerous scheduling conflicts precluded the collection of compelling probe data. As discussed, the study was conducted during a relaxed non-busy time of the year. Subjects would often save tasks to use during in-office probes, thus causing the entire situation to be more artificial than would have been optimal. Ideally, probes would have occurred while the subject was engaged in normal work activities, rather than a brief prepared session. A future study could use video equipment mounted unobtrusively and operated according to a pre-programmed schedule in subjects' offices in addition to laboratory training. This would not only yield acceptable generalization and maintenance data with a minimum of reactivity, but also would allow subjects to receive extensive feedback on their behaviors during actual work tasks.

Peer and Self-Modeling. Videotaped data would also lend themselves to both peer and self-modeling packages to enhance the effects of self-monitoring. Self-modeling would allow subjects to view their own which had been edited to display only optimal levels of performance. Modeling would be maximized with this technique because research has shown that the success of modeling increases with the number of characteristics the subjects and model share (Bandura, 1965; Dowrick & Dove, 1980), and obviously, subjects share all characteristics with themselves. Carroll and Bandura (1982), Miller and Gabbard (1988), Hultman (1986) and others have demonstrated modeling to be an extremely effective tool in the modification of a wide variety of both fine and gross motor behaviors.

Videotaped samples of both the subject and peers could be used for discrimination training and feedback.

In conjunction with self-monitoring, videotaped samples could also be used periodically for subjects to rate their own behavior in the same manner as experimental data is gathered. This would also provide feedback on the accuracy of their self-monitored data. Between such sessions, peers could be used to provide both accuracy assessments and feedback. An additional advantage is that a combination of peer and self-monitoring automatically builds external surveillance into the self-monitoring package. High levels of external surveillance have been found to increase the effectiveness and maintenance of self recording systems (Baskett, 1985; Kopp, 1988; Lee & Piersel, 1989). Of course, some type of external surveillance on the peers would also be required from management to support its continuation.

Longitudinal Data. The chronicity of the syndrome and limited diagnostic abilities prevent an accurate measure of pure risk reduction over short periods of time. A long term study spanning several years and with a large number of participants would be an ideal approach. Similar to the pre-screening tools used here (medical history combined with nerve conduction velocity to determine a rough risk category), subjects could be tested for indications of CTS periodically over the years. The impact of a training program such as the current study could be determined via a comparison between treatment and control groups.

Initially, all workstations would be rated for ergonomic acceptability: those not meeting national standards (ANSI/HFS, 1988) would be modified accordingly. Then, subjects would be randomly divided into control and treatment groups. All subjects would receive identical medical testing and information throughout the study, but only the treatment subjects would participate in an ongoing training system. The author expects that an investigation of this type would reveal distinct differences between the groups over time. The treatment group would likely demonstrate less subjective discomfort, better biomechanics and a lower incidence of CTDs. Through an intensive study such as this, perhaps additional personal and biomechanical risk factors would also be uncovered, adding to the extensive medical and ergonomic literature.

Summary

In conclusion, although the impact of any individual element of the intervention is unknown, it is evident that the combination of techniques (training, self-monitoring, feedback, goal-setting and reinforcement) were highly effective and influenced the behaviors in the desired ways. Overall, posture improved dramatically and hand-wrist positions were far closer to the optimal positions at the completion of the study than prior to it. All involved individuals, the subjects, experimenters and the organization were extremely pleased with both the process and the outcome of the research. In this setting, the threat of CTDs has been tempered at least temporarily.

"Cumulative trauma", "RSIs" and "carpal tunnel" have emerged as buzz words of the nineties in the field of occupational safety and health. Medical, ergonomic, business, trade and layman publications are replete with articles detailing the rapidly growing problem and calling for aggressive action. The finger of blame has been pointed at many: keyboard manufacturers, office equipment designers, software engineers, rate-monitoring management, surgery-prone physicians and many others. The problem does not belong to one group alone - and no single source can provide the ideal solution. Instead, a comprehensive approach incorporating the latest in ergonomic design, biomechanical knowledge, behavioral training and management strategies will yield the most promising solutions. The training discussed in the current work is intended to integrate with other disciplines and it is believed that it is part of a viable solution to one of the many problems that seem to accompany the computer age.

APPENDIX A

INFORMED CONSENT FORM

As you may know, technological advances have resulted in many individuals spending their entire day at work in front of a computer and keyboard. Although it may not appear to be dangerous, hazards associated with prolonged use of such equipment are being identified. Some of these fall under the category of Cumulative Trauma Disorders (CTDs). CTDs result from rapid repeated motions over extensive periods of time. In data entry, the hands, wrists and arms are prone to such injuries. Many people, including doctors, physical therapists, and engineers are trying to find ways to decrease the risk of people getting CTDs.

I believe that one way to do this is to get people to change their behavior in small ways while they are working. That is why I am asking for your cooperation and contribution to this project. The more research that can be done, the better off we are in fighting this occupational injury.

This research project is designed to determine the specific motions of the hand and wrist which are normally used when entering information on a computer keyboard.

One method of assessing the risk of CTDs is by measuring how long it takes for nerves to send signals along their pathways in the hands and wrists. This is called Nerve Conduction Velocity and can be measured quite easily. Should you elect to participated, you will be asked to fill out a brief questionnaire and this will be followed by measurement of your Nerve Conduction Velocity. This is a brief (5 minutes) non-invasive process and will not cause you harm or discomfort. Your arm will rest on the testing device and you will feel a slight tingling sensation in your hand. This test is not intended to diagnose or predict your risk of CTDs. Rather, it is an instrument that will allow me to broadly assess the effect typing behavior has on the functioning of the hand and wrist. This is very much like a scale is used to assess the effect eating behavior has on body size. This testing procedure will be carried out at the start and finish of the project, and a couple of times during the research process.

The project will consist of two phases. During the first phase you will be observed by myself and/or a trained research assistant for a brief duration while entering information at a computer keyboard. A videocamera will be used to record your behavior.

In the second phase, I will talk to you about the specific motions we are interested in and share with you the results of the initial observations. Following this, the observations will continue and you will be provided with frequent feedback on exactly what we have recorded. Additionally, you will be provided with training which may enable you to decrease your risk of contracting CTDs.

None of this information will be used in any way to evaluate your performance. All information about you will remain strictly confidential, and the videotapes will be viewed only by myself, the research assistant, and supervising faculty.

Your decision to participate or not to participate is entirely your own. The main advantage is the contribution you may make ultimately toward preventing job related injuries.

Should you choose to participate, you will be given a summary of the project upon its completion. The data from this study will be used by me in partial fulfillment of my graduate school requirements at the University of Massachusetts and may be used for publication in professional journals and/or for presentation at professional conferences. As in all research such as this, neither participants' names nor any identifying characteristics will be made public from this study without their explicit consent at the time.

The project will last for approximately 4-6 months. Your participation is totally voluntary. Therefore, while I hope you would plan to participate for the duration of the study, you should feel free to withdraw at any time without any penalty. If you have any questions at all regarding this project, feel free to call me at the number below.

Thank you for your time and consideration. Please return this form and indicate your participation to participate below.

Kathleen E. Blake
(413) 545-0794

I have read the above and agree to participate in this study. I understand that I may withdraw at any time.

Kathleen E. Blake
Tobin 516
545-0794

____
Name (please print)

____
Signature

____
Date

APPENDIX B

SUBJECT INFORMATION FORM

Subjects were asked to provide answers to the following questions on an OP-Scan form.

Gender
Date of Birth
Height and weight
Which hand do you write with?
Which hand do you work with most?
Have you ever been tested by OPD before?

DIABETES

- Does anyone in your family have diabetes?
- Do you have diabetes?
- If you have diabetes, and are receiving treatment, what kind of treatment is it?
    - Special diet?
    - Oral medication?
    - Insulin injection?

THYROID CONDITION

- Does anyone in your family have a thyroid condition?
- Do you have a thyroid condition?
- Are you taking thyroid medication?

YOUR HANDS AND ARMS

- Do your hands ever "fall asleep" - in other words, do they ever feel funny, numb or tingly?
- If your hands do "fall asleep", how often does it happen?
    - More than once a month?
    - More than once a week?
    - Every night?
- Do your fingers ever "lock" or "get stuck"?
- Do you have any pains or troubles with your arms?
- Do you ever have any pain in either of your wrists?

- Do your ever have any pain in either of you elbows?
- Do you ever have any pain in either shoulder?

FOR WOMEN ONLY

- Are you currently taking birth control pills?
- Are you pregnant?
- At a certain age, some women tend to stop having menstrual periods regularly.
    - Have you stopped having regular periods?
    - If so, are you taking hormones?

YOUR HOBBIES

- When not at work, do you frequently participate in any of the following?
    - Needle Work?
    - Racquet Sports?
    - Piano Playing?
    - Wood Working?
    - Computer Games?
    - Hair Dressing?
    - Painting?
    - Motor Cycle Riding?

APPENDIX C

SUBJECT BEHAVIOR CHECKLISTS

\+ item present
\- item absent

POSTURE

	Interval 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Back straight																				
Shoulders relaxed																				
Neck straight																				
Feet flat on floor																				
Forearms parallel to floor																				

HAND-WRIST ANGLE

Right Hand

	Trial 1	2	3	4	5	6	7	8	9	10
Extension										
Flexion										

Extension: N =_____ $\bar{X}$ =_____

Flexion: N =_____ $\bar{X}$ =_____

Left Hand

	Trial 1	2	3	4	5	6	7	8	9	10
Extension										
Flexion										

Extension: N =_____ $\bar{X}$ =_____

Flexion: N =_____ $\bar{X}$ =_____

APPENDIX D

DISCRIMINATION TRAINING MATERIALS

CARPAL TUNNEL SYNDROME

What is it?

Carpal Tunnel Syndrome (CTS) is a nerve entrapment disorder which occurs when the median nerve is compressed. The median nerve passes through the center of the wrist through the carpal tunnel - several tendons and other nerves also pass through this space. The median nerve is responsible for feelings in your palm and the palmar side of your thumb, index finger, middle finger and one-half of your ring finger - your pinky has a different nerve. When the space in the tunnel becomes tight, the median nerve gets compressed and it does not function normally.

How do I know if I might have it?

The symptoms of CTS are as follows:

- severe pain, tingling and/or numbness in the hand, especially one that occurs at night and may wake you
- noticeable weakness and loss of strength in hand
- sudden clumsiness - you may find yourself dropping things (such as a gallon of milk, or your coffee mug)
- loss of dexterity - your hand may just not operate as smoothly, you may have trouble picking up small objects, such as a pin
- loss of sensation to vibration and/or temperature
- a growing level of pain in a variety of tasks that persists and does not improve with time or rest

If you are experiencing several of the above symptoms, you may have a problem with the nerve. We all experience the above to one degree or another at times. Occasional reports of the symptoms following tasks such as a lot of gardening, painting, or other jobs you don't normally do is probably not an indication of CTS. However, if the conditions persist, you may have cause for concern. **ONLY A QUALIFIED PHYSICIAN CAN DIAGNOSE CTS - PLEASE SEEK PROFESSIONAL HELP IF YOU FEEL YOU NEED FURTHER ASSISTANCE AND EVALUATION.**

Who is at risk?

There are two main categories of risk factors:

PERSONAL/BIOLOGICAL

- females are at a greater risk than males because they have congenitally smaller wrists, and therefore, a smaller space for the nerve to pass through

- a history of arthritis, tendinitis, diabetes, sprains, breaks and other injuries, and congenital abnormalities of the hands, wrists and arm

- pregnancy induced CTS is common, and usually subsides once the pregnancy has ended

- a history of severe edema (water/fluid retention)

OCCUPATIONAL/BIOMECHANICAL

- repetitive tasks, such as keyboard entry tasks, use of a computer mouse, assembly line work, other work which occurs at a high pace for extended lengths of time, etc.

- tasks which require a high level of force, such as continued turning of a lever, lifting or moving heavy materials, heavy use of cutting tools such as scissors, etc.

- hobbies and other activities which require high repetition and/or force such as: needlework, carving, playing an instrument, video and computer games, and many other fine crafts and activities

- tasks which require constrained or awkward body positions, such as reaching across a table which is too wide, or using a tool at an odd angle which is difficult to do

The presence of any of the above does not indicate that you will get or must have CTS - it does, however, place you at an increased risk. Of the two categories of risk factors, occupational and biomechanical factors are usually responsible for most CTS. Fortunately, these can also be more easily identified and controlled.

What happens if someone does have CTS?

If someone is diagnosed with CTS, the following may occur - (these are presented in order of least to most severe):

- rest and exercises to strengthen the hands and wrists

- splints to keep the wrists in a neutral position - one that doesn't allow the wrist to bend

- diuretics (to reduce swelling) and mild pain killers

- steroid injections into the wrist tissues

- surgery to relieve pressure in the carpal canal

If the condition can be linked to some occupational factor:

- job rotation
- reduction or cessation of repetitive and high force tasks

What can be done to prevent CTS?

The main preventive measures focus on occupational and biomechanical factors. There are certain body positions and ways to perform high-risk tasks that may significantly reduce the risk of getting CTS.

ERGONOMIC CHANGES

Ergonomics is the science of workstation design. Industrial and Human Factors Engineers evaluate a task and redesign it to reduce repetition, force, and the need for awkward and constrained body positions. The proper height of a work bench, angle of a tool, and position of a chair are all determined by ergonomists.

BEHAVIORAL CHANGES

Once the workstation has the best design possible, people can be trained to interact with it in the safest manner. For example, the most expensive chair can be manufactured, but it is of little use unless people are informed about the proper posture and know how to effectively adjust the chair for themselves.

KEYBOARD TASKS

REDUCING THE RISK OF CTS

Keyboard entry tasks, such as word processing, data entry and editing, involve biomechanical factors which make it high risk. There are several things that can be done to alleviate this risk, and therefore reduce the chances that an operator will develop CTS. Following basic ergonomic design of the workstation, there are specific ways that you should interact with it. These fall into two main categories: posture and hand-wrist positions.

CORRECT POSTURE

BACK STRAIGHT	The spine should be at a 90 degree angle from the seat (a right angle)
SHOULDERS	Shoulders should not hunch up or to the
RELAXED	side, both shoulders should be even and a line from one shoulder to the other should form a T shape with the spine
NECK STRAIGHT	Line of neck and head should be a natural continuation of the spine, chin should not be in contact with either chest or shoulders
FEET FLAT	Both feet should be flat on the floor with both heels and toes touching the floor. Legs should not be crossed or tucked behind and under the chair. If necessary, feet should be placed on a platform to achieve this posture
ARMS EVEN	Arms from elbows to wrists should be even with the floor (parallel)

CORRECT HAND-WRIST POSITION

HANDS AND WRISTS STRAIGHT

The line connecting hands and wrists should be straight - the top of the hand is even with the top of the forearm. Hands and wrists should not rest on either the keyboard or on the edge of the table. Hands and wrists should be kept in the same straight position as they would be in if they were laying flat on the table - this is called the **NEUTRAL** POSITION and allows the nerve to pass through the wrist with the least amount of friction and resistance. (Think about what good piano teachers always say - keep your hands and wrists up and straight.

RECOMMENDATIONS

The behaviors listed above, correct posture and a neutral hand-wrist position, should be used whenever you are using the keyboard (the same holds true if you are using a mouse). Adjust the workstation if you need to (i.e., lower chair, move keyboard).

* **REMEMBER** - NO one position is "perfect" and should be maintained at all times. If you are at a keyboard for long periods of time, frequent breaks should be taken. Every 45 minutes, get up and walk around a bit. Stretch your back and legs and shake out your hands and arms. If at any point you feel uncomfortable or stiff, that is a signal to take a brief break from the task. **LISTEN** to what your body is telling you - don't ignore pain or discomfort, even if it is slight. It is better to rest and resume work safely than to continue and risk possible injury.

Display Card: Please place this card where you can see it while you are using your keyboard.

PROTECT YOURSELF

- ✓ BACK STRAIGHT
- ✓ SHOULDERS RELAXED
- ✓ NECK STRAIGHT
- ✓ FEET FLAT
- ✓ FOREARMS EVEN WITH FLOOR
- ✓ HANDS AND WRISTS STRAIGHT

REMEMBER Every hour get up and stretch your back, walk around a bit! You'll feel better!

APPENDIX E

SELF-MONITORING FORMS

Self-Monitoring Posture Form

DATE:	/	/	/	/	/	/	/	
BACK								
SHOULDERS								
NECK								
FEET								
ARMS								
MEAN								

Self-Monitoring Hand-Wrist Form

DATE:	/	/	/	/	/	/	/	
% OF TIME AT NEUTRAL								

APPENDIX F

CONSUMER SATISFACTION SURVEY

Subject responses are provided beside each question. Either the number of subjects responding (N) is provided, or, when appropriate, the mean and range of scores is provided.

Consumer Satisfaction Survey

It would be very helpful for me to get some feedback concerning your participation in the study. I am interested in what you liked, disliked and what improvements should be made. Please take a few minutes to answer the questions below. Thank you.

1. The duration of the study was

		N
a)	shorter than I expected	(2)
b)	longer than I expected	(2)
c)	about what I expected	(2)

2. The amount of time and effort required of you was

		N
a)	very little	(2)
b)	a little	(4)
c)	a large amount	(0)

3. Please rate your reaction to the following:

1	2	3	4	5	6	7
(-)						(+)

a) being videotaped and observed in the lab

Mean = 4.8 Range 2-7

b) being observed in your office

Mean = 4.7 Range 3-7

c) receiving feedback from the graphs

Mean = 6.8 Range 6-7

d) receiving feedback from the experimenter

Mean = 7.0   Range 7-7

e) the close proximity of the observer

Mean = 6.5   Range 5-7

4. How useful did you find the information you learned?

	N
a) very useful	(6)
b) somewhat useful	(0)
c) not useful	(0)

5. How difficult did you find the following:

1 not difficult	2	3	4	5	6	7 very difficult

a) changing to and maintaining correct posture in the lab

Mean = 2.0   Range 1-3

b) changing to and maintaining correct posture in your office

Mean = 2.0   Range 1-3

c) trying to type with your hands in the correct position in the lab

Mean = 4.0   Range 1-7

d) trying to type with your hands in the correct position in your office

Mean = 4.5   Range 1-7

6. Please rate the following based on how comfortable each behavior is to you:

1	2	3	4	5	6	7
not comfortable						very comfortable

a) your posture before the study

Mean = 5.3 Range 4-7

b) the posture taught in the study

Mean = 5.7 Range 3-7

c) your hand position before the study

Mean = 4.5 Range 1-7

d) the hand position taught in the study

Mean = 4.5 Range 1-7

7. How do you feel other people would respond to the process you participated in?

	N
a) very well	(4)
b) adequate	(2)
c) not well	(1)

8. In what ways have you changed your behavior (both at work and at home, typing and other tasks) as a result of the information you learned in the study? Please explain.

9. Do you feel that the original explanation of the study was accurate and sufficient enough that you knew what to expect? If not, please comment.

10. Any comments you have, good and bad, or suggestions would be appreciated.

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