

TREATMENT EFFICACY OF A NEUROBEHAVIORAL REHABILITATION
PROGRAM FOR DECREASING AGGRESSIVE BEHAVIORS
EXHIBITED BY TWO INDIVIDUALS WITH
FRONTAL LOBE DAMAGE

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ABSTRACT

TREATMENT EFFICACY OF A NEUROBEHAVIORAL REHABILITATION PROGRAM FOR DECREASING AGGRESSIVE BEHAVIORS EXHIBITED BY TWO INDIVIDUALS WITH FRONTAL LOBE DAMAGE

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The purpose of this study was to examine the outcomes of a behavior modification treatment program for decreasing aggressive behaviors displayed by two frontal-lobe damaged individuals, one male and one female. Both subjects received inpatient treatment in a secure unit specializing in the treatment of behavior disorders following traumatic head injury. The treatment consisted of implementing individualized behavior modification plans that targeted physically and verbally aggressive behaviors. It was hypothesized that following the introduction of these behavior modification plans, both subjects' verbal, physical, and combined (i.e., verbal + physical) aggressive episodes would decrease significantly. In addition, once these subjects were discharged from the program, they would continue to display significantly fewer aggressive episodes than prior to treatment.

A post-discharge questionnaire was developed to assess the generalization of treatment effect outside of the rehabilitation program. To address the major issues of this study, Auto Regressive Moving Average (ARIMA), t -test, and regression analyses were performed. For subject 1, significant decreases were found for verbally, physically, and combined aggressive behaviors. Similar results were found for subject 2. The results of the post-discharge

questionnaire revealed that the subjects' significant decreases in physically and verbally aggressive behaviors were generalized to the community, with both subjects displaying approximately two verbal outbursts per week and no physically aggressive episodes. The results of this study suggest that behavior modification is a valuable resource for the behavioral rehabilitation of the head injured population. The single subject experimental design and ARIMA analysis appear to be useful for evaluating such treatment interventions. Recommendations for similar behavioral rehabilitation settings are presented, as well as directions for future research.

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I owe the sincerest of gratefulness to my Mother and Father for all the support they have given and continue to give to me. Finally, I want to express my deepest gratitude and admiration to Marcie for her unconditional confidence in me.

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INTRODUCTION

Rehabilitation is a process that assists individuals in modifying their behavior through the learning or relearning of skills and strategies. The goal of rehabilitation is for individuals to reduce and adapt to the social challenge accompanied by the loss or damage of such skills (Wood, 1990). Within the area of neurological rehabilitation, approximately 750,000 Americans suffered traumatic head injuries requiring hospitalization in 1983 (Barker & Ruhen, 1985). In 1988, approximately 25% of all motor vehicle accidents resulted in injuries to the victims' head and neck (National Safety Council, 1991). Currently, approximately one to two million United States citizens suffer from some form of traumatic head injury (Dahl, 1993). There are several explanations to account for this apparent rise, such as a more reliable tracking, increased risks, and higher survival rates. Nevertheless, it appears that the number of traumatic head injuries in the United States has increased dramatically within the past 10 years. With such a significant increase, a concern arises for specialized rehabilitation programs to meet the growing needs of this population.

A recent government report noted that the number of hospitals specialized in neurological rehabilitation has increased from a dozen in 1980 to over 700 currently (Committee on Government Operations, 1992). However, in contrast to the advances that have been made in the acute medical care of the traumatically head injured, behavioral rehabilitation lags far behind (Wood & Eames, 1989).

Behavioral disorders, which are quite common following traumatic head injury, are not currently part of most established rehabilitation treatment regimens (Mateer & Ruff, 1990). Therefore, the development of programs focusing specifically on the behavior disorders of head injured individuals is an exigency (Foster, 1988). A presupposition of this present study is that behavioral rehabilitation facilitates the return of head injured individuals to the most independent and unrestricted living arrangements possible.

During certain stages of recovery from traumatic head injury, patients may become frankly aggressive. Of the many descriptions of this phenomenon, one has been termed "transient combativeness." This is described as a cluster of behaviors in which a head injured patient may physically strike out against others, objects, and self (Wood & Cope, 1989). The duration of this period is unpredictable; whereas some patients remain aggressive for short periods of time, others have lingered in such an agitated state for extended periods of time. Regardless of etiology, these types of behaviors can substantially impede the rehabilitation process of the individuals experiencing them (Lezak, 1983).

Because of the hindrance that such behavior disorders can cause in daily therapeutic interactions, it appears necessary to develop treatment programs that focus on decreasing aggressive behavior, while increasing therapy participation. The present study examined one such program developed at a hospital specialized for head trauma rehabilitation. Through the implementation of individualized behavior modification plans, this program attempts to decrease the occurrences of disordered behavior and, consequently, enhance the rehabilitation process.

The behavioral effects of traumatic head injury vary in degrees of impairment and prognoses for recovery. Due to such a vast heterogeneity of traumatic head injuries, the scope of this study was limited to those patients who presented with aggressive behavior and diagnostic data confirming frontal lobe involvement. Literature exists suggesting that aggressive behavior occurs frequently following frontal lobe damage (for a comprehensive review, see Kandel and Freed, 1989; McGlynn, 1991).

Before describing this neurobehavioral rehabilitation program, it seems obligatory to describe the cortex defined as the frontal lobe. A review of the literature concerning aggression as a consequence of frontal lobe damage will also be provided. Additionally, since this program is based on the fundamental principles of operant conditioning, a presentation of the literature detailing the implementation of behavior modification intervention techniques with head injured patients will be given.

The Frontal Lobe

In mammals, the proportion of brain defined as the frontal cortex ranges from 3% in cats to 15% in chimpanzees to as much as 33% in Humans. Phylogenetically, the human frontal lobe is the latest area to develop, reflecting its unique status in evolution (Stuss & Benson, 1986). Compared across all organisms, it has been suggested that the large frontal lobe of the homo sapiens separates *us* from *them*.

Kolb and Whishaw contend that there are no other cerebral structures in which lesions can produce such a variety of symptoms and range of interpretations than the frontal lobe (1990). These authors remarked that frontal lobe damage has been documented as a source of significant behavior change for well over a century. The behavioral and

cognitive disturbances that occur following frontal damage have been studied and noted in psychological and medical literature.

As its name implies, the frontal lobe is the most anterior structure of the cortex (see Figure 1). Nonetheless, Stuss and Benson (1986) have noted that the frontal lobe can be defined in a number of ways. These include morphological descriptions, the known connections of the frontal lobes to other cerebral areas, and division through biochemical (i.e., neurotransmitter) systems serving the frontal lobe.

In an elementary approach, the frontal lobe is presumed to be symmetrical and is divided into three areas: lateral, medial, and inferior (Mattson & Levin, 1990). Laterally, the frontal lobe is defined as the entire brain area lying anteriorly to the central sulcus (Kolb & Whishaw, 1990) and above the lateral fissure. Medially, it surrounds the anterior section of the corpus callosum and is posterior to an imaginary line dropped from the medial portion of the central sulcus to the corpus callosum. From the inferior surface, the frontal lobe is identified as bordering the temporal lobes laterally and posteriorly, and by an imaginary medial line drawn side to side at the level of the optic chiasm (Stuss & Benson, 1986).

In 1909, Brodmann was the first to use a cytoarchitectonic approach to chart the brain's surface. This mapping of the cortex is currently one of the most widely used classification methodologies in neuroscience. In essence, Brodmann marked specific areas of the brain according to cell structure. According to the Brodmann Map, the frontal lobe is classified as including areas 6, 8, 9, 10, 46, 45, 44, 11, 47, 32, and 13. Although this map does

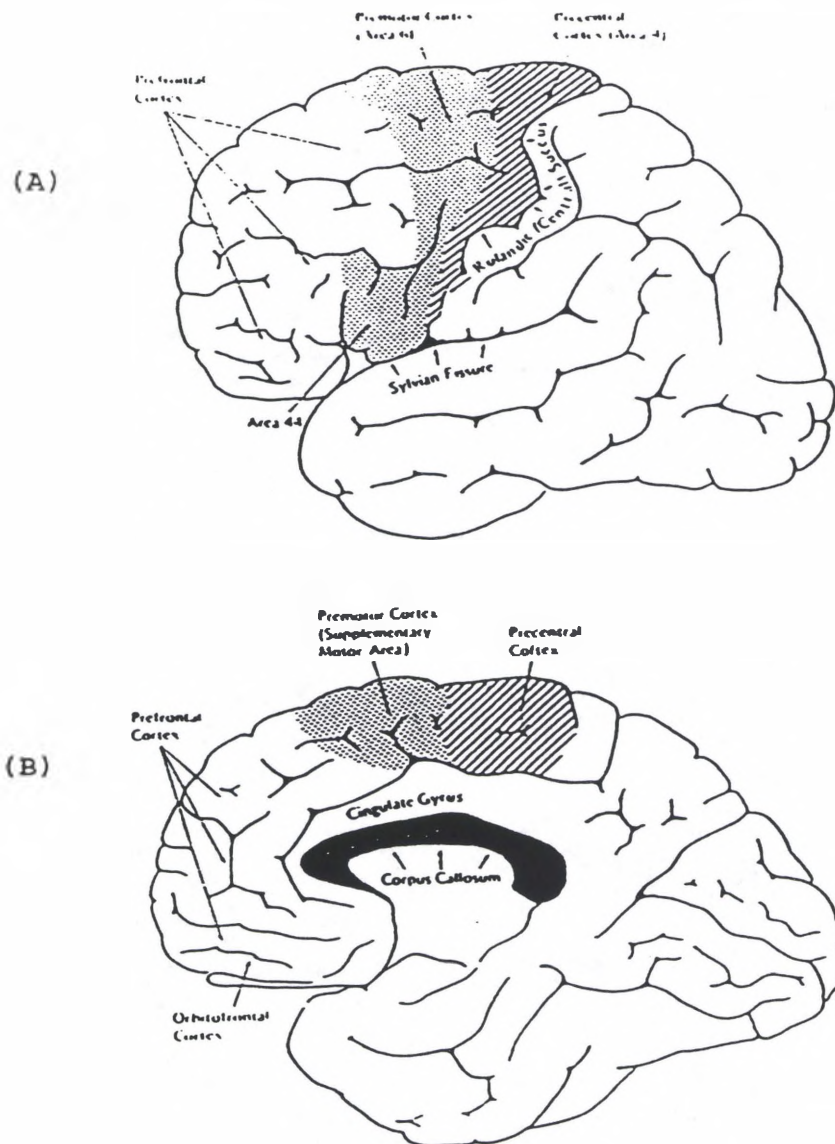


Figure 1. (A) lateral and (B) medial views of the human cerebral hemisphere (Damasio, 1985).

not denote functional regions of the brain, it correlates well with those that do, such as the map created by Penfield and his coworkers (Penfield & Jasper, 1954).

The cerebral hemispheres are frequently defined by their underlying cortical cytoarchitectural structure (Brodmann, 1914). These various cell layers of the cortex also have significant functional characteristics. Neocortex consists of approximately six layers: I, the molecular layer; II, the external granular layer; III, the external pyramidal layer; IV, the internal granular layer; V, the internal pyramidal layer; and VI, the polymorphic layer. These cell layers can be separated into two functional groups. The outer four layers receive axons from other brain areas while the inner two layers send axons to other brain areas (Kolb & Whishaw, 1990).

The prefrontal cortex has rich neural connections with most regions of the central nervous system (Nauta, 1971). Among these are thalamic-, limbic-, and various other subcortical connections. Most of these pathways proceed through the dorsal medial nucleus of the thalamus to the orbital-frontal cortex or the convexity (i.e., lateral dorsal medial nucleus cells). There are also efferent limbic connections that traverse directly to the cingulate gyrus (Pandya, Van Hoesen, & Mesulam, 1981).

There are three connections between the brain stem and the frontal lobe (Porrino & Goldman-Rakic, 1982). These connections run to the dorsal-lateral prefrontal and cingulate cortex from the ventral midbrain, the central superior nucleus and caudal portion of the dorsal raphe nucleus, and the locus ceruleus and proximal medial parabrachial nucleus. There are a number of other frontal

connection areas in the cortex including frontal-cortical sensory connections, frontal-olfactory connections, and frontal-motor connections (Nauta, 1971; Stuss & Benson, 1986).

The most important connections of the frontal lobe may be those with the motor structures (i.e., the basal ganglia), those with medial temporal structures, and those in the spatial and recognition systems of the parietal and temporal cortex (Kolb & Whishaw, 1990). The rich connections of the frontal lobe with other cerebral areas suggest that the frontal lobe plays a role in most stimuli processing. Lesions in the frontal cortex may affect functions in other brain sites. The complexity and breadth of frontal lobe connections undoubtedly contribute to the vast array of behavioral changes observed in individuals with lesions in this region. This notion lends itself to the contention that localized functions are not as "localized" as previously thought.

The research focusing on frontal cortex neurotransmitter systems is relatively exiguous. Currently, dopamine is considered to have the best established relation with the frontal lobe. Dopamine systems are distributed throughout the frontal lobe, including the medial prefrontal area, the dorsal-medial nucleus, and the cingulate gyrus. The highest concentration of dopamine appears to be in the medial cortex (Lindvall et al., 1978).

Bannon and Roth (1983) noted indications that the dopaminergic prefrontal system has certain peculiar properties. Dopamine appears to play a somewhat different transmitter or modulator role in the frontal lobe than elsewhere in the neocortex. Fuster (1989) examined that patterns of dopamine distribution in the brain and suggested

that it plays a major role in the neural integration and support of motor action. It seems that such a high concentration of dopamine in the frontal lobe serves to mediate the organization and execution of motor behavior.

Norepinephrine, the second major neurotransmitter found in the frontal lobe, innervates the frontal lobe in a more widespread area and has a more even distribution than dopamine. By amount, however, there is less norepinephrine than dopamine in the frontal lobe. There are two known norepinephrine systems (Moore, 1982). One originates from the locus ceruleus, transverses the cortex, and supplies the thalamus and cerebellum. The second proceeds from the reticular formation and innervates the hypothalamus, brainstem, and spinal cord.

It is difficult to infer any specific function for norepinephrine from its patterns of distribution. Because it has such a widespread distribution throughout the cerebral cortex, it is presumed to mediate many different functions. Nevertheless, the relatively high concentration of norepinephrine in the prefrontal cortex makes it reasonable to presuppose that this neurotransmitter plays a special role in the mediation of integrative cortical functions that support the processing of somatosensory information (Fuster, 1989).

Other neurotransmitters such as acetylcholine, glutamate, gamma-amino-butyric acid (GABA), and serotonin have been found in the frontal cortex (Emson & Koob, 1978; Stuss & Benson, 1982). Acetylcholine systems have been implicated in arousal activity. Electrical stimulation of the brainstem reticular formation causes the release of acetylcholine in widespread cortical areas, including the frontal lobe. The combination of the brainstem reticular

formation being electrically stimulated and the release of acetylcholine causes electrocortical arousal (Fuster, 1989). GABA is presumed to serve all inhibitory interneurons, which are found practically everywhere in the central nervous system. GABA has been reported to perform that function in the prefrontal cortex as well (Emson & Lindvall, 1979). The serotonergic system is believed to be involved in the processing of sensory information.

Research concerning maturation of the human brain is limited. This is due to: (1) the shortage of human subjects in the early stages of development for study; (2) the inappropriateness of animal models to explain human cortical development; and (3) the preponderance of human developmental individual differences (Stuss & Benson, 1986). However, certain patterns of frontal lobe development appear to be relatively consistent.

During prenatal development, the presence of cortical gyri appears to vary. At birth, major gyri are present and distinguishable (Chi, Dooling, & Gilles, 1977). Shaping of the cortical surface by tertiary sulcation continues through life, but the exact pattern is unclear.

Neuronal proliferation and synaptogenesis in the human frontal cortex reach a peak between 1- and 2 years of age. Functions mediated by the frontal lobe, though, continue to emerge throughout adolescence and into young adulthood (Goldman-Rakic, 1987). From a neurobiological perspective, cognitive and behavioral development during this period is poorly understood. Morphological maturation of the prefrontal cortex is reached approximately during puberty, although changes continue throughout the lifespan.

Huttenlocher (1979) suggested that synaptic density increases over the first year of life to a level well above adult levels and then declines over the next 16 years. Research has demonstrated that there were no changes in synaptic density between the ages of 16 and 72 years, and a slight decrease in the sample of 74-90 year old brains. Overproduction of synapses in the infant frontal cortex is similar in other cortical regions, appearing to be a general characteristic of brain development.

Theories of Frontal Lobe Functioning

With a basic presentation of the anatomy, physiology, and development of the frontal lobe, it is now appropriate to examine the functions controlled by the frontal lobe. The following theories delineate the functions of the frontal lobe.

In Pribram's view, the brain systems associated with problem-solving can be divided into two neuroanatomical areas (Pribram, 1960). The more posterior areas of the brain are involved in the discrimination of a basic problem. Once a problem is identified, intentional behavior is then commanded by the more anterior (i.e., frontal) system. Pribram's theory is based on a feedback system. Pribram contended that a far more intricate explanation of behavior is needed than the reflex arc. This complex system included a feedback loop, acting as a fundamental process. Along with Miller et al. (1960), Pribram formulated the test-operate-test-exit (TOTE) system. They assumed that a state of incongruity exists between the organism and the stimulus, and that testing continues until this incongruity is resolved. For Pribram, the TOTE system is an organizing and coordinating unit, not a simple reflex.

The TOTE is the most fundamental unit of behavior. Larger operational units are possible, consisting of multiple TOTES, each with its own feedback loop. This provides a hierarchical structure controlling both the constructions and sequences of the tasks to be performed. Action of the organism is an external representation of the neuroprograms in the brain.

Pribram postulated that intentions are formulated in the posterior regions and transferred to the frontal lobe. Following frontal lobe damage, behavior lacks context due to inappropriate or absent schedules or routines (i.e., the neuroprograms), resulting in impaired or impulsive behavior and planning. Pribram hypothesized that "the frontal cortex is especially concerned in structuring context-dependent behaviors" (Pribram, 1973, p. 308), which is a function of higher-order control. It can be inferred that an individual with frontal lobe damage may become quite frustrated when attempting to process context-dependent information, which could lead to aggressive behavior.

The basis for Nauta's theory of frontal lobe functioning is grounded in neuroanatomy. On reviewing the anatomy of the frontal lobe, Nauta (1971) observed two related phenomena. First, the frontal lobe has a strong reciprocal relation with two significant functional zones, the sensory (i.e., visual, auditory, and somatosensory) zone and the telencephalic limbic system. Second, with their associations to the limbic system, the frontal lobe represents the major neocortical representation of the limbic system. These two frontal lobe functions assist in monitoring the internal milieu and providing information for affective and motivational responses.

The bountiful connections of the frontal lobe to almost every cerebral area suggest that the frontal lobe can act as an effector and sensor (Nauta, 1973). As an effector, the frontal lobe plans, programs, and modulates; as a sensor the frontal lobe is involved in perceptual processing.

Nauta presented a neuroanatomical rationale for the presetting of the external processing systems. There is also a mechanism in the frontal lobe that presets the internal processing systems. This presetting, as described by behavioral foresight and anticipation, is mediated by frontal-limbic connections. The behavior of frontal lobe damaged patients, such as apathy and aggression, may result from damage to these systems. These behaviors occur because the patient with frontal lobe damage cannot affect or process internal and/or external phenomena (i.e., foresight, planning).

The theory presented by Damasio (1985) is somewhat similar to Nauta's. Damasio, however, incorporated a more functional aspect in his anatomical model. Three basic factors underlie this model. First, the principle of behavior is the preservation of an individual's equilibrium. Second, the general functions of the frontal lobe are to judge and regulate ongoing external perception and to plan the appropriate response. Finally, there are the anatomical considerations underlying these functions. This is a meaningful inclusion, given the reciprocal connections of the frontal lobe with: (a) the reticular activating system and the limbic system; (b) the posterior sensory association areas; and (c) the cortical and subcortical systems.

Damasio alleged that the frontal lobe provides analyses and comparisons within a stimulus-response network. The frontal lobe not only determines how the sensory information

should be analyzed, but also determines the response to accomplish the most beneficial consequences. This occurs through a series of gating mechanisms. There are such systems for the evaluation of pleasure and pain. This system is automatic. Complex information, that involves internal and external rules, requires a more deliberate gating mechanism. This involves learning. Damasio hypothesized that more of the action programs can be carried out by nonfrontal areas as learning becomes increasingly consolidated. Thus, the relative preservation of measured intelligence after frontal lobe damage can be explained.

A. R. Luria, the famous Soviet neuropsychologist, presented the frontal lobe as being responsible for the most important tasks in planning and designing behavior. Luria (1973) postulated three functional units of the brain. The first unit regulates wakefulness and mental tone; the second receives, analyzes, and retains information; and the third program regulates and verifies mental activity. These three distinct functional units have different neuroanatomical representations.

Unit 1 is located in the subcortical areas, particularly the reticular activating system, receiving most of its connections from the orbital and medial frontal cortex. Unit 2 is located in the posterior portion of the brain and consists of the visual, auditory, and parietal cortical regions and their connections. Unit 3 is located in the frontal lobe and acts primarily as a motor effector in contrast to the afferent action of the second unit. Although all three units work in unison, the frontal lobe acts as the facilitator. Higher mental functions, such as

planning and regulating, are developed within the frontal lobe and are implemented through language. Not only does the frontal lobe create programs, it monitors them.

Luria's theory is quite anatomically specific, yet his descriptions of frontal lobe functions remain general. Emphasizing the importance of the frontal lobes in many brain functions, Luria does not attempt to correlate these activities with localized frontal functions.

These are but a few of the theories of frontal lobe functioning and a sample of the research that has been conducted. It is noteworthy that, although the preceding researchers presented varying functional theories of the frontal lobe, there are common themes. Most notable is that the frontal lobe acts as a mediator for higher mental processes. In patients with frontal lobe damage, behavior is often disorganized. One possible consequence of this is that aggressive behaviors may present due to the inability of the frontal lobe to regulate impulses originating in the limbic areas, decreased ability to process context-dependent information, and decreased monitoring of input from various cortical areas.

Behavioral Sequelae of Frontal Lobe Damage

It has been suggested that the study of the relation between the frontal lobe and behavior began in 1936 when Moniz noted decreased anxiety in patients who had undergone prefrontal lobotomies (Kandel & Freed, 1989). Historically, claims about the functions of the frontal lobe have been extreme and extravagant. From the time of Gall and the phrenologists until the 1930's, the frontal lobe was thought to be the seat of the highest intellectual and moral functioning (Halstead, 1947; Rylander, 1939). Functions such

as foresight, intellectual synthesis, ethical behavior, affect, and self-awareness were all reported to be under the influence of the frontal lobe (Kolb & Whishaw, 1990).

However, in the late 1930s, psychologist Donald Hebb questioned these views (Hebb, 1939). He had administered standard intelligence tests to four patients who had undergone a frontal lobotomy for the treatment of epilepsy. He found that there was no significant change in their test performance from their pre-injury scores. In other words, measured intelligence did not decrease after frontal lobe removal. This study motivated researchers to examine the functions of the frontal lobe under closer scrutiny.

Stuss and Benson (1986) have noted that a great deal of research has been conducted concerning the behavior of patients with frontal lobe lesions. These authors also note that this research has all too often yielded inconsistent results. This has led many to the conclusion that the activities of the frontal lobe are a riddle.

Several reasons can be noted for the establishment of such a puzzle. Many frontal lobe lesions produce no primary neurological deficits. Furthermore, inadequate assessment instruments, lack of control groups, and varied groups of deficits can all confound frontal lobe research in particular, and neuroscience research in general. Finally, frontal lobe pathology is often misinterpreted as a psychiatric, non-organic, problem.

Nonetheless, research has yielded common functional disorders that accompany frontal lobe damage. Of all the frontal lobe functions, the control of motor responses is the most obvious. In 1872, Meynert recognized that the frontal portion of the brain subsumed motor actions, in contrast to the sensory actions of the parietal, temporal, and occipital

lobes (Stuss & Benson, 1984). Two of the most significant portions of the frontal lobe, the pre-central and pre-motor areas, have been studied extensively. Two major forms of apraxia following frontal lobe pathology have been distinguished. The first results in a problem in the execution of dexterous movements. The second, and more common, concerns the motor program itself, which is so disturbed that the scheme of an action is replaced by an inert stereotype (Henneman, 1980).

Evidence has accumulated suggesting that the frontal lobe serves the motor areas as well as the sensory areas (Damasio, Damasio, & Chui, 1980). It has been contended that the frontal lobe is relevant to the unilateral inattention phenomenon, as well as a number of other types of visual neglect (Heilman & Valenstein, 1972). Teuber (1964) observed that frontal lobe lesions in either hemisphere produced a decrease in performance on tests of perception when compared to other brain-damaged and control groups. Other visual-perceptual tasks have also been shown to be sensitive to frontal lobe pathology (Walsh, 1978).

Damage to the frontal lobe classically results in confusion, disordered arousal and alertness, and impairment of attention. Many of the frontal deficits described by Luria (1973) can be considered deficits of attention. Disturbance of attention is a common observation after frontal lobe damage. Hecaen and Albert (1975, p. 139) note:

"From the first examination of the (frontal lobe damaged) patient, the disorder of attention is noticeable; it is necessary to repeat questions and orders several times to obtain a response."

The occurrence of language disorders following frontal lobe pathology has been recognized since the demonstrations of the French neurologist Broca in 1865. They generally

involve Broca and transcortical aphasias and have been studied extensively (Luria, 1966; Mohr, 1973). These disorders involve the diminished capacity to comprehend or communicate verbally. Supplementary motor area disturbances have been noted to produce output language deficits (Alexander & Schmidt, 1980).

Other functions diminished by frontal lobe damage cited in the research literature include memory (Stuss & Benson, 1984), abnormal awareness (Freedman & Kaplan, 1975), perseveration (Luria, 1973), and other cognitive functions (Ackerly & Benton, 1947; Milner, 1982). With a description of common deficits of frontal lobe pathology presented, it is now necessary to focus on the aggressive behavior presented by patients with frontal lobe lesions.

Probably the most widely accepted alteration secondary to frontal lobe pathology concerns changes in personality. Specific descriptions are difficult to present. However, some of the more common behaviors include mood changes, puerile joking, unconcern, grandiosity, egocentricity, and antisocial behavior. Harlow's famous case study of Phineas Gage in 1868 typifies the so-called "frontal personality" (Kolb & Whishaw, 1990). Researchers have attempted to gather their results into a unified entity, often referred to as "the frontal lobe syndrome" (Benton, 1968). Certain behavioral aspects of this phenomenon are observed frequently and include impulsiveness, euphoria, diminished anxiety, lack of initiative, and spontaneity. However, a significant amount of variability appears in the definitions concerning this syndrome.

The temporal state of "confusional combativeness" that occurs in the post-acute interval following frontal lobe injury has been well documented (Bond, 1986). A well-known

measure for assessing cognitive functioning following head injury, the Ranchos Los Amigos Scale of Cognitive Functioning, cites aggressive behavior as an indicator of certain functional levels. Miller (1985) discovered that persisting aggressive, violent, and impulsive behavior may frequently be encountered in individuals with frontal lobe damage, complicating recovery from head injury. It is this aggressive behavior that can significantly impede therapeutic contact and, subsequently, long-term rehabilitation progress.

Bond (1986) has identified "marked aggressiveness" as one feature of frontal lobe damage due to head injury. Lishman (1973) suggested that bilateral frontal lesions of the orbital areas lead to the most severe examples of irresponsible and antisocial conduct. Aggressive behaviors, such as physical striking out, have been studied throughout the neurological rehabilitation field. It appears that the generalized brain damage occurring in head trauma impairs the mechanisms that inhibit or regulate emotional response. The frontal lobe may be vulnerable to such damage (Mattson & Levin, 1990; Posthuma & Wild, 1988). Bond (1984) has contended that one consequence of this is that the patient has limited control over sudden shifts of mood or the rapid changes in drive that direct behavior. Frustration tolerance also decreases, whereas disorientation and confusion increase. These factors can lead to a lower threshold for exhibiting aggressive behavior.

Frontal lobe based aggression seems to represent an "escape" of aggressive behavior. This is due to the brain's diminished ability to maintain an emotional equilibrium or control the behavioral expression of changes in mood (Miller,

1985). It is because of this that frontal patients typically overreact to minor provocation or frustration (i.e., the "catastrophic reaction" phenomenon).

The most usual form of expression of this behavior occurs when intermittent periods of irritability escalate into an emotional response, the magnitude of which is quite disproportionate to the antecedent. Once begun, the patient seems to have little or no control over the course of the behavior (Miller, 1985). The provocation is typically clear, and the attacks are usually directed toward that source.

As mentioned previously, aggressive behavior may significantly impede a patient's ability to function adaptively, adversely affecting rehabilitation efforts (Lezak, 1983). Mattson and Levin (1990) have suggested that it is imperative to explore treatment programs that may effectively increase the rehabilitation potential of patients with frontal lobe damage who present with aggressive behavior.

One intervention that has had success in the treatment of a wide variety of psychological and organic disorders is behavior modification. Extensive literature is available showing the outcomes of behavioral methods with various clinical populations (Fidura et al., 1987; Kazdin, 1980).

The use of behavior modification with the brain injured population is less documented, and only a small amount of literature is available, mostly in the form of single case designs. This lack of research is often mentioned in the existing literature. Authors point to the studies that exist touting their promising results, while lamenting the scarcity of research in this area. Despite the limited documentation of behavior modification interventions used with the brain injured population, it has been widely recommended as a

choice of treatment for this population. It appears that behavior modification is used quite frequently with this population, although its use is not highly documented.

Behavioral Treatments for Nonaggressive Behaviors Following Brain Injury

The following section contains accounts of behavioral-based intervention techniques used for the brain injured population suffering from various forms of disordered behavior. These include attention and motivation, unawareness of deficits, and memory, language, and speech disturbances.

Attentional and motivational deficits pose serious problems for the rehabilitation process (McGlynn, 1990). Wood (1984) and Ince (1976) have contended that behavioral techniques may be the most effective and efficient interventions for dealing with these problems.

Webster and Scott (1983) developed a behavioral approach to treat a head injured patient with attentional problems. This patient, referred to as H. D., had mild cognitive impairments and difficulties with new learning and remembering. He was administered a self-instructional program that targeted his attention deficits. This program consisted of two parts. In the first part, he was told to use self-instruction statements to prepare himself to listen and to ask for repetition if he became distracted. In the second part, he was instructed to read aloud, and eventually to himself, every sentence of a paragraph. Post-treatment assessment showed that his attention, as measured by recall of information, had increased significantly. An 18-month

follow-up assessment revealed that his attention had maintained its post-treatment efficiency, indicating some generalization.

Malec (1984) discussed this self-instructional paradigm for attending to appropriate stimuli for use with the brain injured population. A case was presented in which a self-instructional paradigm, comparable to Webster and Scott's, was administered. Similar results were found.

Wood (1986) implemented traditional behavioral methods to increase attentive behavior and improve information processing in four head injured patients. Two training tasks were designed. The first required patients to monitor a random series of numbers presented on audiotape and to respond each time a target sequence of three numbers was heard. For each correct noted sequence, tokens were given to provide reinforcement. The second, a visual attention task, involved matching symbols on one side of a panel with symbols on another. The symbols on the other panel were placed in a different order. Patients received positive and negative feedback for correct and wrong answers, respectively. Analysis of the training results indicated that every patient showed a significant improvement for both components.

Wood and Eames (1981) described two behavioral methods for eliciting productive behaviors from brain injured clients. One method included positive reinforcement, in the form of tokens, for spontaneous and desirable behaviors. The second included a shaping program in which successive behaviors 'chained' together were reinforced with tokens. In both treatment tasks, improvements in productive behaviors were seen.

A majority of brain injured individuals lack insight into the consequences of their injuries (McGlynn & Schachter, 1989). The neurological rehabilitation literature has noted this phenomenon and the complications that may arise from it (Brooks & Lincoln, 1984; Cicerone & Tupper, 1986).

Prigatano and Fordyce (1986) included enhanced awareness as a primary rehabilitation goal in their multidisciplinary program. This program is based on behavioral principles and includes awareness training, self-report checklists, and video recording. Patients are actively included in the rehabilitation process and receive extensive support and reinforcement from the staff. The feedback and support system, paired with the patients' participation in goal-setting, have yielded significant results.

McGlynn, Schachter, and Glisky (1987) increased awareness in a severely amnesic patient who lacked significant insight into his memory problems. An awareness training paradigm was implemented, involving giving the patient lists of words, having him predict his performance, and then providing extensive discussion concerning his performance. Following 6 weeks of this program, the patient's predictions of performance became closer to his actual performance and his responses to self-report questionnaires indicated that he increased his acknowledgment of his deficits. These findings suggest that amnesic patients may develop some awareness of their deficits with appropriate treatment.

Memory impairment is one of the most common sequelae of brain injury or disease and can have a marked impact on the patient's ability to function in everyday life (Levin et al.,

1982). Wilson (1984) described several behavioral principles that could be valuable for memory rehabilitation including shaping, chaining, prompting, and modeling.

Fowler, Hart, and Sheehan (1972) were among the first to apply behavioral techniques to develop treatment interventions for head injured patients with memory impairments. An attempt was made to manipulate the environment of a hospital to permit patients to live independently. Schedules of daily activities and portable timers were given to all patients. The patients were instructed to set these timers for 5 minutes before the next scheduled appointment. The timer served as an effective cue to find the time, look at the schedule, and reset the timer for the next session. One patient who displayed consistent tardiness to therapy, was on time to all scheduled therapies after 3 weeks of using this strategy.

Jaffe and Katz (1975) implemented a verbal prompting and fading technique to teach a patient with Korsakoff's syndrome to learn and recall names. The patient, who was not able to recall names of the staff of the hospital where he had stayed for over 2 years, was provided with the name of the staff member, and a strategy for recalling that name every time he encountered the staff member. Upon the next encounter, the patient attempted to name the staff member, and if he could not, would be cued from the recall strategy. Eventually, the patient could recall names of staff members on his floor. Seidel and Hodgkinson (1979) were able to replicate these results by using similar strategies.

McGlynn (1990) reported that behavioral interventions have been applied to patients with speech and language disturbances. Holland (1967) discussed the applications and

clinical utility of behavioral principles in the rehabilitation of such deficits and the positive results that have been obtained.

Holland and Harris (1968) reported a detailed case study in the rehabilitation of aphasia using programmed instruction. This strategy was performed for 5 hours per week over an 8-month period. Results of this training program indicated substantial improvement in conversational responses, written language, and more rapid, fluent speech.

Smith (1974) reported the use of operant conditioning procedures in the reeducation of syntax in two aphasic patients. These individuals were taught by a two-stage procedure to use prepositions and word order to convey the nature and direction of a spatial relationship. A series of investigations by Goodkin (1966) applied behavioral principles of reinforcement, punishment, and modeling to the treatment of various speech disturbances. The target behaviors included increasing the frequency of the patient's comprehensible words, decreasing the infrequency of incomprehensible words, and the decreasing of perseverative responses. Positive results were yielded using these principles.

These brief descriptions support behavioral methods for treatment of common deficits displayed by patients with brain injury. The following section will focus on behavioral intervention strategies for socially inappropriate and aggressive behaviors.

Behavioral Interventions for Aggressive Behaviors Following Brain Injury

Disruptive social behavior frequently characterizes persons with head injuries, especially those with injuries in frontal lobe areas (Crewe, 1980; McGlynn, 1990; Wood, 1984).

Some of these behaviors are transient and are seen in patients who, in the acute rehabilitation stage, display combative behavior that is typically a result of disorientation and confusion (Foster, 1988). However, lesions of certain regions will produce stable patterns of aggressive behavior. Wood (1984) suggested that the main purpose of using behavior modification techniques with these patients is to control the behaviors that prevent rehabilitation from proceeding.

Hollon (1973) attempted to extinguish disruptive behaviors while concurrently eliciting cooperative behaviors from two brain injured patients. Treatment involved the implementation of positive reinforcement for desirable behaviors, paired with ignoring, to the ethical extent possible, undesirable ones. Target behaviors consisted of howling, spitting, hitting, and scratching. Within a 6-week period the disruptive behaviors significantly decreased. An increase in cooperative behaviors was also noted. Crewe (1980) developed an equivalent program with similar patients and was able to replicate the results.

The token economy is a behavioral system in which patients are rewarded for desirable behaviors with tokens that they can 'cash in' for reinforcers (e.g., candy, watching television). This type of intervention has been successful in treating aggressive behaviors (Goldstein & Ruthven, 1983; Hurwitz, 1973; Whaley et al., 1986). However, a major limitation to these procedures is that the patients being given the tokens must understand the economic design inherent in the system. Cognitive deficits, which are present in a majority of brain injured individuals, could

interfere with their learning of this system. Therefore, while widely accepted as a successful behavior intervention, the token economy has this limitation.

Wood and Eames (1981) discussed several effective techniques for controlling inappropriate behaviors. This included "time out from positive reinforcement" to reduce aggressive and disruptive behavior in two brain injured patients. For the first patient, every instance of aggressive behavior was coupled with "time out on the spot" (i.e., the patient was ignored completely for a brief time immediately following the behavior). Substantial improvement occurred over the course of 12 weeks. The second patient was moved from a group activity room into the corridor for every instance of disrupting the group. Treatment continued for 16 days, at which point the disruptive behavior was virtually eliminated. Wood and Eames (1984) suggested that an effective means of modifying behavior is the use of a time out room, a confined area in which minimal stimulation can occur.

Lira, Carne, and Masri (1983) implemented Meichenbaum's stress inoculation training to treat anger and impulsivity in a highly functional brain injured client. This patient exhibited low frustration tolerance that culminated in violent outbursts. Stress inoculation training consisted of three phases: (a) cognitive preparation to educate the patient about the appropriate ways of expressing anger; (b) skill acquisition including cognitive reappraisal of anger-evoking events; and (c) application training to practice such skill development. Treatment efficacy was assessed over a 4-week period and it was determined that these violent

outbursts significantly decreased. A 5-month follow-up assessment revealed continued acquisition and implementation of the techniques learned.

Brotherton et al. (1988) focused on the remediation of documented disruptive behaviors of four head injured patients. The research used single case methodology in the form of a multiple baseline across behaviors design. Specific social skills training was clearly effective for 3 of the 4 patients. Training was more effective when applied to simple, motoric target behaviors (e.g., posture) than when applied to more complex behaviors (e.g., positive verbal statements). Maintenance of treatment effects was observed 1 year later.

Horton and Howe (1981) presented the application of behavioral interventions to a brain injured individual presenting with a history of biting behavior. A CT scan revealed a right frontal lesion. A behavioral treatment using a report-card and response-cost system was implemented. Staff members recorded the number of incidents of biting, kicking, and hitting staff members on a daily basis. At the end of the day, the staff would give the patient feedback and a treat/reinforcer (i.e., 3 oz. of vanilla ice cream) if no target behaviors had occurred. However, if these behaviors had occurred, then the ice cream was withheld (i.e., the response-cost scenario). Target behaviors became almost nonexistent, and the improvement generalized to other therapy settings.

Burke and Lewis (1986) reported the case of a point system, similar to a token economy, implemented to reduce the frequency of socially maladaptive behavior exhibited by a head injured individual. This individual consistently displayed disruptive behavior during meal time. The patient

was told that for every 4-minute span of appropriate behavior during meal time he would receive one point. If he attained four out of five possible points during a meal (meal time was 20 minutes), he would be able to choose an item from a reinforcement menu. These items included soft drinks, magazines, and a 7-minute walk with a staff member. Results indicated that the patient was able to reduce the occurrence of disruptive behaviors. There was a slight increase of verbal outbursts after the treatment was withdrawn, but these outbursts remained significantly fewer than before treatment.

Wood and Cope (1989) described the development a specialized rehabilitation ward designed to treat aggressive and socially inappropriate behaviors named the Kemsley Unit. The unit's structured environment utilized a variety of behavior modification techniques in conjunction with one another, such as time out, response cost, and schedules of reinforcement to treat severely debilitating behaviors. During their lengths of stay, 30 patients were monitored for increases of desirable behavior and decreases in aggressive behaviors. All patients displayed a decrease in aggressive behaviors and an increase in desirable behavior. Individual differences were noted, with some patients improving more than others. However, the overwhelming evidence suggests that "...whatever the origin of post-traumatic aggression, a successful outcome can be obtained using behavioral methods..." (Wood & Cope, p. 81, 1989). The Kemsley Unit has been noted elsewhere in the literature as a reputable and successful behavior modification facility for the treatment of aggressive behaviors displayed by head injured individuals (Eames, 1988; Wood, 1987).

Limitations do exist concerning the application of behavioral principles in neurobehavioral rehabilitation. McGlynn (1990) cited generalization as the most prominent shortcoming of the implementation of these principles with the head injured population. The main purpose of rehabilitation is to provide handicapped individuals with a repertoire of skills that will facilitate their adaptation and function in everyday life. If the skills the individual acquires during the rehabilitation process cannot be maintained in this everyday life, then the rehabilitation program has not benefited that individual. McGlynn examined the existing literature and determined that the research concerning transfer-of-training is scarce (1990).

The literature that does examine the generalization of behavioral principles outside the rehabilitation program presents a nebulous picture. It appears that there is a complex interaction of variables that determines such generalization. First, individuals who are motivated to improve their level of functioning are more likely to apply what they have learned to outside situations than individuals who are ambivalent about their treatment progress (McGlynn, 1990). Second, individuals with severe cognitive deficits may possess certain neurological constraints preventing them from effectively implementing their acquired knowledge in different contexts (Glisky & Schachter, 1986). Third, particular types of behavioral techniques may be more effective for generalizing the learned behavior. Currently, this issue is quite relevant and being pursued.

Wilson (1984) noted a number of methodological flaws that need to be addressed in future research. First, there are not enough systematic single-case experimental studies from which to draw firm conclusions about the efficacy of

behavioral techniques. It appears that although single case designs are often implemented in the clinical realm, they are not prominent within the research literature. Second, the single-case experimental designs that have been reported are often a simple AB design and do not use multiple baselines. Thus, it is often difficult to evaluate the extent to which treatment is attributable to the intervention as opposed to spontaneous recovery or nonspecific therapeutic influences. Third, reports of behavior change as a function of treatment too often rely on subjective impressions rather than on quantitative assessments of behavior.

Nonetheless, with the amount of literature presented in this section, it appears that behavioral techniques can be a valuable tool in the treatment of behavior disorders that result from head injury. As Foster (1988) has suggested, behavior modification techniques are easy to learn and implement. There are, however, certain conditions that will influence the efficacy of treatment. Howard (1988) states that there are seven characteristics of effective behavior management programs. These are: structure, consistency, repetition, specificity, practicality, appropriateness of rewards, and meaningfulness. Brain injured individuals are environmentally dependent, due to confused and disoriented internal states. Structure provides the external security that patients can manifest internally. Patients need to perform the same tasks often to establish a routine. Routines assist in alleviating confusion and disorientation. Brain injured patients often have marked deficits in attention and generalization. It is wise to focus on specific, concrete goals that are relevant to the rehabilitation process. The application of positive reinforcement to increase desired behavior is fundamental to

the behavior modification process, and the rewards offered must be appropriate (i.e., desirable) enough to warrant change. If a consequence is not salient to the client, the client will not want to change his/her behavior to obtain the reward. Finally, patients are more likely to give effort to achieve goals that they judge to be pertinent to their needs.

Behavior modification techniques represent a successful intervention in the rehabilitation of brain injured individuals. Aggressive behaviors have also been shown to be affected by these techniques. It appears that behavioral treatment methods can serve the rehabilitation clinician well and should be kept in their arsenal of treatment options.

The Neurobehavioral Rehabilitation Program

This section will describe the characteristics of the neurobehavioral rehabilitation program, portraying the staffing, coverage, and physical characteristics, as well as criteria for admission, development and implementation of behavior modification plans, and discharge. This specially designed program exists independently within a hospital that offers rehabilitation services exclusively to those individuals who have suffered traumatic head injuries. The hospital, which has a capacity to house approximately 150 individuals, is located in a small northeastern city. The program specifically addresses issues concerning the behavioral rehabilitation of patients with traumatic head injury.

The development of this highly specialized program focused on the concern that patients exhibiting behavioral disorders should not be denied rehabilitation services due to the threat of their potentially harmful behavior as a result of a traumatic head injury. As mentioned, rehabilitation

services are often impeded when an individual presents with aggressive behavior. It is likely that such an individual will not receive the quality of services that non-aggressive head injured individuals would receive. It is the policy of this program that individuals experiencing behavioral difficulties be treated for their behavioral or social skills deficits and not be denied treatment. This course of action implies that behavioral rehabilitation is as specialized, authentic, and feasible a treatment modality as is cognitive and physical rehabilitation (Foster, 1988).

Specialized employees function as staff in the neurobehavioral program. These employees, the neurobehavior technicians (NBT), provide direct behavior management services for all patients in the program. A neurobehavior technician's training consists of methods in verbal and physical crisis intervention as well as applied behavior therapy. NBTs are used in every case whenever a threat of aggression exists, or when the patient is on a formal contingency management or reinforcement program.

The NBTs are responsible for all data recording. This consists of monitoring patient behavior and recording the time, duration, type, and description of any behaviors targeted for remediation, as well as patient status throughout the day (see Appendix A). The NBTs remark on patient behavior in 15-minute intervals unless otherwise specified. Specific recording forms and techniques are developed by the operational definitions detailed in the behavior management plans and enhance NBT recording reliability.

The neurobehavior technician supervisor (NBTS) is an NBT who has demonstrated exceptional response to training, and superior leadership and interpersonal skills. The NBTSs are

responsible for all aspects of the program on their respective shifts, in direct consultation with the program coordinator and director. NBTSSs are not assigned to direct coverage except in the most extreme situations. Their role is primarily to supervise the conduct of the NBTs in the implementation of behavior modification plans and to provide additional personnel during crises.

The program coordinator and director are responsible for the administrative duties of the program. These duties consist of assessing potential admissions, providing training sessions in verbal and physical crisis intervention and applied behavior therapy, and tracking patient progress. The program coordinator is a masters-level psychologist and the director is a doctoral-level neuropsychologist.

Neuropsychology therapists, who have been assigned to individual patients throughout the facility, under the supervision of the program director, develop specific behavior modification plans for their patients. These therapists are responsible for elucidating the goals of the plans to the program coordinator, NBTSSs, and NBTs.

Core program staff consist of nurses, nursing aids, and specialized rehabilitation therapists (e.g., occupational, physical, and speech/language therapists). These individuals implement their respective services within the context of the behavior modification programs. In all instances, they are provided with behavior therapy training, crisis intervention, and the knowledge of current behavior plans for all patients residing in the wing.

Whereas there are a specified number of certain professionals working in the wing, other positions may fluctuate depending on various factors, including number of patients in the wing. One program director, one program

coordinator, and three neurobehavior technician shift supervisors are permanently assigned to the program. The number of neurobehavior technicians, nursing, and therapy staff changes as a function of the patient to staff ratio.

This neurobehavioral program is located in a secure wing of the hospital. "Secure wing" is defined as a portion of the hospital that has ingress and egress by authorization only. An individual requesting entrance to or exit from the wing must do so through the staff at the nursing station. The main entrance to the wing is locked and is only opened when access is granted. This serves two very important functions. First, many patients who experience head injury aimlessly wander during certain stages of their recovery (Goldstein & Oakley, 1985). This behavior may result in elopement and subsequent risk of patient harm is increased. In the secure wing, the patient may wander, but is not able to leave the rehabilitation area. This increases patient safety, welfare, and independence, since staff are always able to monitor patients' status. Second, a closed wing allows for greater environmental control and structure regarding the administration of behavior modification plans.

The neurobehavioral program wing consists of a number of different rooms to allow for maximum patient rehabilitation (see Figure 2). There are nine patient bedrooms; six are semi-private and the remaining three are private. Thus, 15 beds are available within the wing. The multipurpose room consists of an ADL kitchen, patient dining area, and occupational/physical therapy area. This room is most often used by rehabilitation therapists in the delivery of their services. A nursing station is centrally located within the wing. A patient smoking lounge is available within the wing. For patient leisure, this lounge also contains video

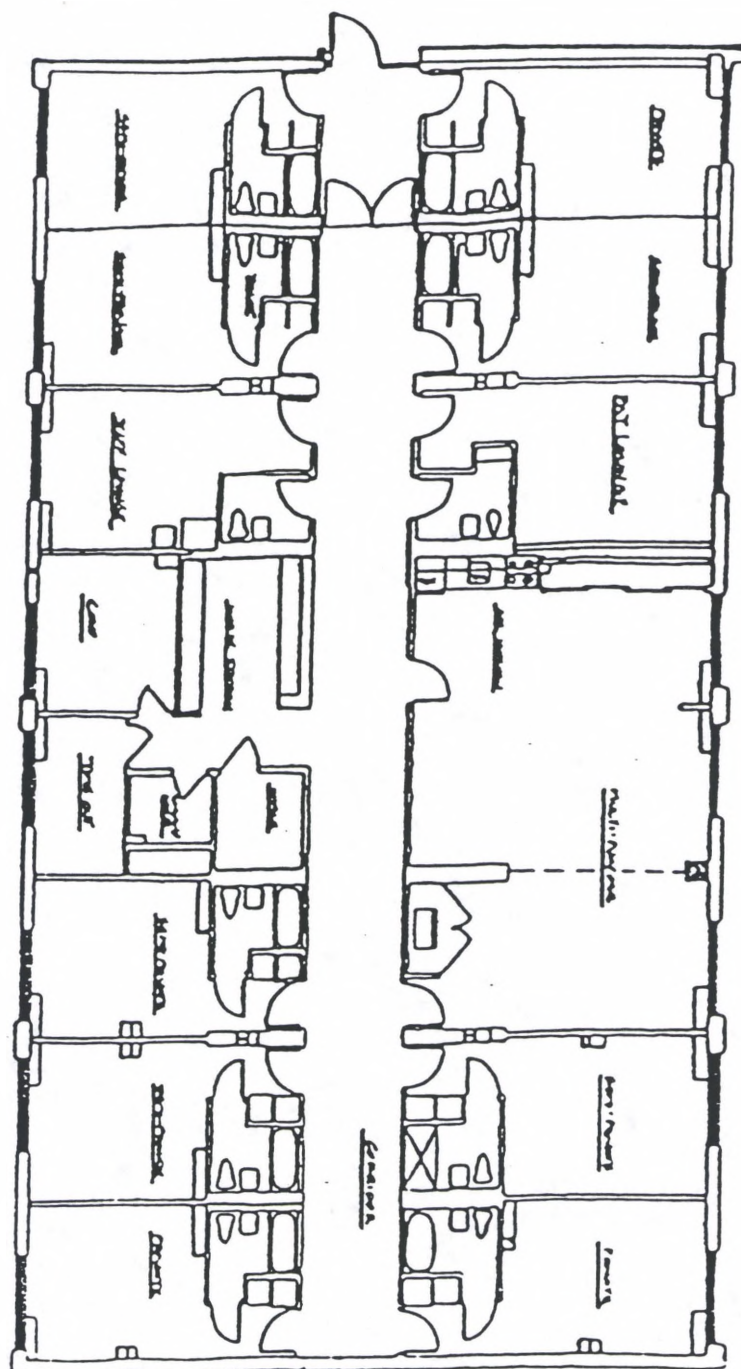


Figure 2. Ground plan of the neurobehavioral program wing.

equipment, such as television, video cassette recorder, and video game set. A time-out room is located near the nursing station. This room is designated as a safe place for patients in times of dyscontrol, when physical restraint is not called for in a behavior plan. For administrative purposes, the program coordinator's office is located behind the nursing station and is next to a staff conference room. A staff lounge is also adjacent to the nursing station.

All rooms, with the exception of the conference room, staff lounge, and coordinator's office, are equipped with video surveillance cameras. From the conference room, the neurobehavioral staff is able to monitor patients' behavior unobtrusively. This serves many purposes, including the monitoring of patients in time out and insuring that they will not harm themselves. It also allows the coordinator and director to observe physical restraint procedures to ensure that these are implemented safely and ethically. Objective notes may be taken during such procedures to modify treatment plans if a particular intervention is not having a desired effect.

Each NBT and NBTS, coordinator, and director are also required to carry two-way audio communication devices (i.e., walkie-talkies). With these devices, the staff is able to communicate with each other when they are not in the proximity of the person with whom they wish to talk. Staff is also able to call for assistance during episodes of patient dyscontrol that require more personnel.

The implementation of behavior modification plans occurs through direct coverage of patients by NBT's. In other words, a minimum of one NBT is always within a short distance of a patient. There are five categories of behavior coverage for patients in the Neurobehavioral Program. These

categories range from multiple NBTs covering one patient, to the unobtrusive observation of a patient by an NBT.

In the 1:1 coverage category, one NBT is in visual contact with a patient always. Physical proximity can vary depending on the reason for such coverage. The implementation of the individualized behavior plan is the responsibility of this NBT. Other NBTs and/or staff may be asked to assist in the behavioral intervention during crises.

Multiple NBT coverage is used when the threat of physical confrontation exists or when assaultive behavior is likely to occur. Minimally two NBTs are in visual contact with the patient at all times. One NBT is within arm's reach and intervenes verbally while other NBTs remain in proximity until needed. This coverage is most often used sporadically, although it can also be relatively permanent for assaultive patients on progressive calming protocols as defined in their treatment plans. Multiple coverage is provided due to the potential for the need of physical restraint and to safeguard patient and staff welfare.

Close observation coverage consists of one NBT seeking out, observing, and noting a patient's status during 15-minute intervals. House rounds are similar except the interval period is 30 minutes. NBTs may cue patients on such coverage to attend scheduled events, provide direction to such events, and provide support as needed. These manners of coverage also provide less restriction of the patients, while the staff is still able to monitor their behavior closely.

Unobtrusive observation is the least restrictive method of NBT coverage. In this form, one NBT is assigned to a patient and observes and notes the patient's behavior through the assigned period. Attention is on the recording of

behavioral frequencies as well as antecedent and consequent environmental and individual circumstances. Although the NBT remains inconspicuous, intervention is guaranteed for episodes representing immediate risk and/or harm.

These varying degrees of patient coverage allow for the implementation of many behavior modification procedures. Reinforcement can be delivered quite expediently to patients during instances of appropriate behavior. Inappropriate behaviors can be ignored, to the extent possible, while inconspicuously monitoring patient behavior. Multiple coverage of an aggressive patient decreases the risk of harm to that patient, other staff, and other patients. Finally, multiple behavioral procedures can be implemented. For example, NBTs may provide reinforcement to a patient for attending therapy, while later restraining this patient for attempting to strike out at the therapist.

Admission to the neurobehavioral program is considered appropriate when a current or prospective individual demonstrates any behaviors suggestive of risk of harm to self and/or others. These behaviors may also include those that interfere with return to home or placement facilities, or those that otherwise interfere with the patient's rehabilitation progress.

An individual may be admitted to the program through either of two routes. By way of the first route, a prospective admission, from another facility or home, may be referred by the rehabilitation consultant or intake coordinator. Referral made by these professionals before admission is based on reports regarding behavioral difficulties obtained from medical records, the referral facility, the patient's family, or from their own observations during on-site visits. The rehabilitation

consultant or intake coordinator then submits an information form to the clinical director of neurobehavioral rehabilitation and director of neuropsychology for review. These individuals review this form and determine the type and nature of expected coverage, as well as when coverage can begin.

In the second route, a patient already in house may be referred by the interdisciplinary team, or any member of that team, during the patient's rehabilitation program at the hospital. As their rehabilitation progresses, patients already in house may reach a level of recovery wherein their behavior becomes dangerous, interferes with therapies, or is otherwise problematic to the rehabilitation process. In these cases, a referral is made to the primary neuropsychology department therapist. This therapist then informs the clinical director of neurobehavioral rehabilitation and the director of neuropsychology.

If it is determined that this patient presents with behaviors appropriate for admission into the neurobehavioral program, the primary neuropsychology therapist ensures authorization forms are signed and completes a request for NBT coverage. If this patient is deemed not in need of the program, the primary neuropsychology therapist addresses the problem in the normal course of the interdisciplinary team's clinical responsibilities. This includes developing behavioral guidelines or interventions that are implemented by the team or selected members of the team.

Before establishing a formal behavior plan, it is necessary to conduct an assessment of the individual's behavioral difficulties. Typically, this is accomplished by assigning 1:1 NBT coverage to the patient, and having the NBT record episodes of disordered or inappropriate behavior.

These behaviors may include noncompliance to demands, striking out, and low safety awareness. If an individual experiences an episode of behavioral dyscontrol, generic behavior management guidelines have been developed to ensure patient and staff safety. These plans serve as general regulations in cases of such crises.

NBT coverage is assigned to patients depending on the behavior difficulties the patient may be experiencing. Typically, the same number of NBTs work with a client during the day and evening shifts, with one NBT assigned during the night shift. The NBTs assigned are informed of the presenting behavior disorder(s) and are instructed to observe and record each instance of such behavior. This is accomplished by recording the occurrence of the behaviors targeted for remediation by the neuropsychology therapists and describing the antecedent(s) and consequence(s) of the event on the behavior observation forms.

A formal behavior management plan is developed depending the need for immediate intervention. Some patients may manifest dangerous behaviors beginning at the time of admission. If this is so, a formal baseline cannot be established and a plan must be devised expediently. A more formal baseline of behavior can be measured if the patient does not present with immediate behavioral difficulties, and then a treatment can be implemented.

This baseline consists of monitoring and recording instances of behavioral dyscontrol. An assessment focusing on which behaviors requires attention is conducted after a predetermined interval. From this, a formal behavior

modification plan is implemented. This plan is developed by the primary neuropsychology therapist with supervision from the program director.

Once the plan is implemented, NBTs constantly monitor its influence. Interventions are modified if they do not produce desired results. Current plans are assessed to determine effectiveness. The primary neuropsychology therapist accomplishes this by reviewing NBT and interdisciplinary reports concerning the occurrence rates of target behaviors, comparing them to past assessments, and drawing conclusions about patient progress.

As patients demonstrate better self-controlled and determined behavior, NBT supervision is gradually withdrawn. Withdrawal is gradual due to the dependence that most patients experience with such close supervision. Supervision is first reduced by having the NBT leave the patient's field of vision for 5- or 10 minutes during an hour. As the patient tolerates this, lengths of unsupervised time increase until the patient is unsupervised for 30 minutes per hour. If there are no incidents requiring NBT intervention for 3 days, the coverage is further reduced to house rounds. If the patient tolerates house rounds without incident for 3 days, coverage is discontinued altogether.

The Single-Subject Experimental Design

The methodology used in behavioral research is an important consideration in evaluating the efficacy of a given intervention. In the area of head trauma rehabilitation, many varieties of injuries and subsequent behavior disorders can occur. The single case treatment paradigm is frequently encountered in this field (Burke & Lewis, 1986; Horton & Howe, 1981; McGlynn, 1990). Aeschleman (1991) reported that

there has been an increased trend toward the use of single-subject experimental designs (SSED) in the rehabilitation literature. Additionally, single-subject experimental designs have been most often encountered in operant behavior studies (Kazdin, 1975 & 1982).

Gianutsos and Gianutsos (1987) state that the single-subject experimental method is well suited for the needs of the rehabilitation clinician. They contend that its strategies should be prominent among the options for the assessment of rehabilitation treatment efficacy. The single-subject experimental method focuses on the analysis of individuals. The data are typically presented separately for each person. Repeated measurements are recorded so that the data are presented as a function of sessions, trials, or time. This allows for the evaluation of an intervention across a given interval, which controls for spontaneous recovery effects by examining data as they are recorded. SSED data can be graphed continuously as the experiment continues to determine patterns of behavior and as a quick reference for the clinician/researcher as to the effect of a given treatment.

Due to the inherent necessities involved in neurological rehabilitation research, certain methodological standards are likely to be sacrificed. For example, groups of homogeneous clients may not be readily available to study. Additionally, a patient who presents with behavioral difficulties (e.g., a patient who is aggressing against other patients and staff) may require immediate intervention, thus not allowing for a methodologically adequate baseline. In many situations, the clinician/researcher can not afford the strict control of the methodological characteristics that the traditional experimental researcher can (Mateer & Ruff,

1990). However, these disadvantages can be controlled, or at least minimized, with the SSED. As Baron (1990) emphasizes:

"Effects of variables across their range of influence, functional relationships, are examined as they naturally occur, within the same organism rather than as a construction from group performances." (p.168).

Hayes (1981) delineated five essential elements of single case methodology that, when combined, construct logical designs. They are repeated measurement, the establishment of the degree of intrapersonal variability, specification of conditions, replication, and an attitude of investigative play.

The single-subject experimental design is fundamentally a repeated measure, across some determined interval, of a client's behavior. This is simply a priori within the design's definition.

It is necessary to establish the degree of variability in the client's behavior throughout some interval. Determinations must be made about the level and trend in behavior, as well as predictions about the future course of the behavior. This is important for establishing hypotheses about the presenting behavior disorder. For instance, if a client displays consistent aggressive behavior in occupational therapy, but not in any other therapy contexts, it can be hypothesized that a social and/or environmental factor in this therapy area may be responsible for the aggressive behavior.

Regardless of experimental design, all research requires operational definitions of the independent variables. This enables the researcher's audience to grasp precisely what the target behavior is and allows for replication of the experimental conditions.

External validity is the crux of all time series designs (e.g., SSED). Since the single-subject experimental design will typically contain only one subject ($N = 1$), it is imperative that the replication of interventions can occur. This is possible through the specification of conditions. Operationally defined independent variables lead to replicable designs. In other words, a specific treatment must be concretely defined so that this treatment can be reproduced in another independent design. It has been contended that internal validity, with the assistance of operational definitions, may ensure external validity (Bass, 1987). The replication of the treatment intervention to another client of the same population can strengthen the external validity of the intervention.

Hayes (1981) emphasizes that single case research designs should be flexible and ready to change if significant occurrences arise. This is especially significant in the clinical realm. Occasionally a particular client may not respond to a given intervention. In this case, modifications of that given intervention are necessary to maintain beneficial effects for the client. Data should also be graphed frequently to explore the emergence of potential behavioral patterns. Because the SSED occurs prominently in applied clinical designs, the researcher must be aware of the many external circumstances that need to be addressed during intervention.

Although the experimental control of the applied design is important, the clinical results of a given intervention are more important than the statistical results. Occasionally unanticipated effects are encountered and the clinician/researcher must abandon a given intervention for a more immediate intervention.

Various researchers have suggested other elements that an SSED should contain. Hersen and Barlow (1976) remark that phases should be similar in length. Extreme variability between phase lengths can produce errors in interpretation. However, there are statistical procedures that attempt to correct for this occurrence. Another guideline is to change one variable at a time (Hersen & Barlow, 1976). Yet, as Thomas (1978) has emphasized, the word 'variable' can be easily misunderstood, and it is better to think of it as the phase 'condition you wish to analyze.' (p. 69).

Hayes (1981) likened single-subject designs to building blocks. There can be as many specific case designs as there are designs for "brick buildings, and the core elements of each are comparably simple" (p. 197). Hence, there are many designs available to the clinician/researcher. A wide variety of other designs may be developed to meet the needs of the treatment, the client and the clinician/researcher.

Every research design, including the SSED, inherently contains advantages and disadvantages. These may refer to the methodology used, the variables measured, and the population studied. There are also certain misconceptions concerning SSED's that need to be clarified.

The SSED is useful for studying rare or unusual cases. Some of the designs, such as ABAB and multiple baseline across behaviors, are logically complete within each case. Rare or unusual cases may not lend themselves to traditional group designs because of a lack of members for an experimental group.

Single-subject experimental designs also allow the clinician/researcher to track the course of an effect. SSEDs have typically been analyzed visually. The main component of visual analysis is to plot the data graphically and draw

inferences from them through visual inspection. This is especially helpful to the clinician who needs to stay informed of interval to interval, perhaps even day to day, events.

Aeschleman (1991) noted that single-subject designs control for variability from sources other than the treatment at the level of the individual, and more reliable rules relating treatment to individuals are generated. He suggests that for certain areas of psychology primarily concerned with identifying variables that have functional utility at the level of individual clients, the single-subject design approach offers more, not less, external validity.

The single-subject experimental design establishes more control, in methodology and analysis, than the case study. Kazdin (1981b) suggested that single-case experimental designs are just as effective as traditional between-group approaches in controlling for potential confounding, through techniques such as multiple baseline and alternating treatment designs.

In most of the applications of these designs, the clinician/researcher has some degree of flexibility to change the nature of the design as data are evaluated across time. It is also possible to combine design elements to rule out various threats to internal validity. These threats can be ruled out through replication of the experimental effects. (Kratochwill & Williams, 1988).

Single-subject experimental designs are typically in accord with clinical ethics and goals. It is usually the timing of treatment onset, not the provision of treatment, that is varied. Treatment is not withdrawn or excluded from clients, as can be the case with group designs that require a control group (Gianutsos & Gianutsos, 1987). Relatedly, the

single-subject clinician/researcher can specify in great detail the nature of the independent and dependent variables and the characteristics of the setting and client. The nature of the single-subject experimental design is quite compatible with the rehabilitation philosophy of individual-specific care and treatment.

Mateer and Ruff (1990) remarked that the SSED not only avoids the potential ethical and practical restrictions of group designs that withhold treatments, but is also appropriate and productive for the initial stages of research in a new, or sparsely explored, area. Such individually controlled designs may yield research findings that can then be generated into group treatment designs.

Baron (1990) comments that the average performance of a group cannot be relied upon to represent the performance of individual members accurately. A significant effect for a certain group administered a certain intervention can result solely from a high performance of a small number of group members. Single-subject experimental designs dismiss this, since the significant effect of the individual is a result solely from his/her performance.

The most significant disadvantage of single-subject experimental designs is its marked inability for generalization. Whereas group studies are more easily generalized to their parent populations, the single-subject experimental designs cannot justify such generalization per se. Replications of intervention designs are necessary to promote generalization.

The use of statistics in single-subject experimental designs is a relatively new development. Visual analysis of SSED data had been the norm for many years. Kazdin (1982) defined visual analysis as "...reaching a judgment about the

reliability or consistency of intervention effects by visually examining graphed data" (p. 232). The majority of researchers who have relied on visual analysis of SSED data claimed that if the effects are great enough to be noticed by the naked eye they will most likely be statistically significant. Additionally, a small statistical difference may have little clinical utility (Parsonson & Baer, 1978). Visual analysis sorts out independent variables that clearly affect behavior. Tawney and Gast (1984) contend that graphic representation and visual inspection of SSED data provide practitioners with a compact and comprehensive account of individual performance.

Visual inspection is readily subjective, relying on an individual's judgment of a proposed effect. Many researchers have cited this as a problem in the interpretation of single-subject experimental design data (DeProspero & Cohen, 1979; Furlong & Wampold, 1981, 1982; Jones et al., 1978). Kazdin (1982) also reported that visual analysis leads to an increased probability of committing a type II error. The reliance on visual analysis alone can lead to concluding that a specific treatment had little effect on behavior. This can occur when the treatment phase did not visually deviate from the baseline trend even though it deviated in a statistically significant manner.

Probably the strongest argument made in favor of the use of statistical procedures to analyze SSED data is that these procedures are perfectly reliable. Whoever applies the procedures will reach the same statistical results. With visual analysis, interrater reliability is typically low (Suen & Ary, 1989).

Contrasted with visual analysis, time series analysis is a statistical procedure for making inferences about changes in level and trend among several phases of a single-subject experimental design (Jones, Weinrott, & Vaught, 1978). Subjects' scores are displayed over time, with interruptions in the time series designated as the change points of one phase to another. In the typical ABA design, change points occur at the time treatment is introduced and when the return-to-baseline phase is instituted. The main focus for analysis of such time series data is to determine whether the changes in behavior following the interruptions warrant the conclusion that the treatment affected the behavior observed.

Time series analysis has an advantage over other inferential statistical procedures (e.g., ANOVA), as well as visual analysis, in that it can correct for serial dependency. Serial dependency is a common confounding mechanism in behaviorally oriented designs. It refers to the notion that contiguous scores tend to be related to, or predictive of, one another. Jones, Vaught, and Russell (1977) assert that "serial" refers to the temporal order of the scores being an inherent property of the scores. The term "dependency" refers to the relationship between scores in the temporally ordered series. Gibson and Ottenbacher (1988) contend that serial dependency reflects the ability to correlate sequential responses of the same person. Suen and Ary (1989) provide a more detailed explanation and discussion of serial dependency and its effects on statistical analyses.

It is feasible to detect the occurrence and effect that serial dependency may have upon a set of SSED data, enabling the researcher to control its effects. This is accomplished by computing what has been termed the autocorrelation

function (Suen & Ary, 1989). The autocorrelation function is a set of Pearson's product-moment correlation coefficients. The correlation between two different observations of the same variable made at two different points in time is assessed. This procedure allows the researcher to investigate the magnitude of the serial dependency. With this knowledge, adjustments can be made to analyze the SSED data more reliably.

Ottenbacher (1986) suggests that visual and statistical analysis be used in conjunction with each other. In agreement with this position, Bloom and Fischer (1982) state:

"visual inspection of data should be considered a very useful beginning point. But unless the patterns are very clear, with sufficient numbers of observations and with stable baseline data, other methods of analysis should also be employed." (p.439).

However, a study conducted by Jones et al. (1978) led to different conclusions. It was found that when serial dependency was high, visual and time series inferences did not agree. When there was little or no serial dependency, inferential agreement was more likely to be compatible between the two methodologies. Given this assertion, coupled with the notion that statistical analysis yields reliable results across raters, it is suggested that statistical procedures be used in analyzing data with significant serial dependency.

The analysis of the present study will rely solely on statistical procedures. This position is based on the following contentions. Serial dependency is likely to occur in operant research (Hartmann et al., 1980). When serial dependency is present, it will most likely confound the agreement between visual and statistical analyses (Jones et al., 1978). When serial dependency is present, it

contaminates the inferences drawn from visual analysis. This contamination will likely inflate any value of an inferential statistic by 300%-400% (McDowall et al., 1980). There are statistical measures that will account for and remove any effects caused by serially dependent data. Finally, as opposed to the subjective nature involved in visual analysis, statistical procedures produce reliable results independent of who analyzes the data.

From the review of the literature concerned with single-subject experimental designs and the specific techniques used to analyze their data, the SSED appears to be a valuable tool for constructing applied behavioral investigations. The SSED contains many strengths that facilitate its use for data analysis. First, it is useful for studying rare or unusual cases. Second, it allows the clinician/researcher to track the course of a treatment effect. Third, it is in accord with clinical ethics and goals. Finally, it is compatible with the individual treatment philosophy of rehabilitation. Although there are certain limitations to the use of this technique, this does not invalidate its application to the area of applied behavioral analysis in general, and this proposed study in particular. Likewise, the statistical procedures used for the analysis of such designs are valid and valuable.

The Present Study

The purpose of the present study was to conduct a pilot study exploring the treatment efficacy of a neurobehavioral program for decreasing physical and verbal aggression displayed by individuals with frontal lobe damage. For the purposes of the present study, treatment efficacy was defined through two dimensions. First, treatment was determined to be effective if statistically significant decreases in the amount of aggressive episodes occurred during each subject's length of stay in the neurobehavioral program. Second, treatment was deemed effective if the decreased number of aggressive episodes continued following each subject's discharge from the neurobehavioral program.

All former patients of the neurobehavioral program who met the methodological criteria were placed in a sample. Two of these individuals were randomly selected and served as subjects for this study. The selected subjects archival data were then analyzed.

The following hypotheses were proposed:

1. It was predicted that there would be a significant decrease in the number of physically, verbally, and combined aggressive outbursts displayed by both individuals following the implementation of the specific behavior modification procedures.
2. It was predicted that there would be a continuation of decreased physically, verbally, and combined aggressive outbursts following discharge from the neurobehavioral program.

METHOD

Subjects

Two former patients of the neurobehavioral program served as subjects in this study. For inclusion, these subjects met the following prerequisites: (1) localized frontal lobe damage; (2) no preexisting psychiatric disorder; (3) assessed at either level IV or V on the Ranchos Los Amigos Scale of Cognitive Functioning during admission to the program (see Appendix B); and, (4) exhibited physically and verbally aggressive behavior.

The ideal subject for this study would be one who presented with physical and verbal aggressive episodes and an extremely localized frontal lobe lesion. However, it is relatively uncommon for a head injured patient to sustain such focal damage (Stuss & Benson, 1984). Typically, individuals with head injuries will present with multiple and/or diffuse cerebral damage. For the purposes of this study, however, it was necessary to select patients with minimized diffuse cerebral damage. To be selected as subjects, patients must have sustained minimally diffuse frontal lobe damage as evidenced by CT and/or MRI reports. Medical records, such as neurological evaluations and CT scans, provided this information.

Many behaviors exhibited by frontal lobe damaged patients resemble psychiatric disorders (Kandel & Freed, 1989). Selected subjects must not have had preexisting psychiatric disorders, as defined by the Diagnostic and Statistical Manual of Mental Disorder, Third Edition, Revised (American Psychiatric Association, 1987). Prior criminal behavior also discounted any potential subjects.

A well-known measure of cognitive functioning used in this field is the Ranchos Los Amigos Scale of Cognitive Functioning. This scale assesses cognitive functioning through the occurrence of certain behaviors. Aggressive behavior is a characteristic of levels IV and V. Therefore, subjects included in this study must have been assessed at the time of admission as either functioning at level IV or V of the Ranchos scale. This allowed for a concrete, replicable measure that operationally defines subjects' characteristics.

Finally, potential subjects must have displayed physically and verbally aggressive behavior. Physical aggression was defined as physical striking out (e.g., punching, grabbing, kicking, and spitting) that may cause risk and/or harm to other patients, staff members or the patient him/herself. Verbally aggressive behavior was defined as any comment made in an angered tone with a violent intent. Such behaviors included threatening, swearing, and yelling. Since there are a variety of physically and verbally aggressive behaviors, these definitions served only as a guideline. Specific aggressive behaviors were operationally defined per each subject and subsumed under this definition.

All former patients of the neurobehavioral program who met the aforementioned criteria were placed in a sample. Two individuals were randomly selected to serve as subjects for this study. These selected individuals, as well as their legal guardians, were told the nature of the present study and signed a release of information form (see Appendix C). This permitted the examination of their files, including demographic information and behavior frequency data. The selected subjects archival data was then analyzed.

Selected subjects' demographic information was included to present a vivid description of each subject, their potential confounding ability, and for the sake of replication. The following characteristics were described for each selected subject: handedness, age, education level, socioeconomic status, time since onset of injury, length of coma, specific etiology of injury, summaries of relevant psychological and neuropsychological testing results, medical and psychosocial history, and the presence of aphasia and other neurologic deficits.

Patient 1, P. D., is a 30-year old, Caucasian female. She suffered a comminuted and depressed skull fracture in the left frontoparietal region from a motor vehicle accident. Her presenting problems upon admission to the neurobehavioral rehabilitation program were physical aggression, emotional lability, impulsivity, and lack of insight concerning her deficits (see Appendix D).

Patient 2, C. T., is a 40-year old, Caucasian male. C. T. suffered a bifrontal contusion and left frontoparietal intraventricular/intraparenchymal hemorrhage as a result of a motor vehicle accident. His presenting problems upon admission to the neurobehavioral program were physical agitation, such as swearing, spitting, hitting, and kicking, emotional lability, short attention span, decreased frustration tolerance, disorientation to place and time, and decreased short term memory (see Appendix E).

Procedure

P. D.'s behavior management plan was devised to address her physical and verbal outbursts as well as other presenting problems (see Appendix F). For the scope of this study, only her physical and verbal behavior problems are presented. A

verbal outburst was defined as any statement made in an angered tone, above normal speaking volume, including any statement or gesture of expressed physical harm to another person. A physical outburst was defined as an attempt to make physical contact with another person, in anger, usually preceded by an episode of emotional lability and/or a threatening statement.

P. D. was assigned 1:1 NBT coverage. When P. D. exhibited a verbally aggressive episode, staff would provide her with a verbal "stop" cue, stating flatly, "P. D., you are sounding very angry. Take two deep breaths and count to 10 slowly." If P. D. calmed, staff would offer verbal praise and process other means of expressing anger with her. If she did not calm, staff would cease all interaction with her, remove eye contact, and turn away from her.

If she aggressed toward any staff, a progressive calming protocol (see Figure 3) would be initiated. The progressive calming protocol was implemented in the following manner. First, the NBT working with P. D. would call for assistance. After four NBT's arrived, P. D. would be escorted to a quiet place in the room she occupied and have each of her limbs manually restrained. P. D. would be instructed that she must relax her body while being restrained. Upon 15 seconds of total physical relaxation, each limb would be progressively released beginning with her left arm. If P. D. attempted to aggress during this time, staff would begin the entire protocol over. Once P. D. had successfully complied with the protocol's procedure, any previous interaction would resume.

C. T.'s behavior management plan, similar to P. D.'s, addressed various disordered behaviors. Likewise, the scope

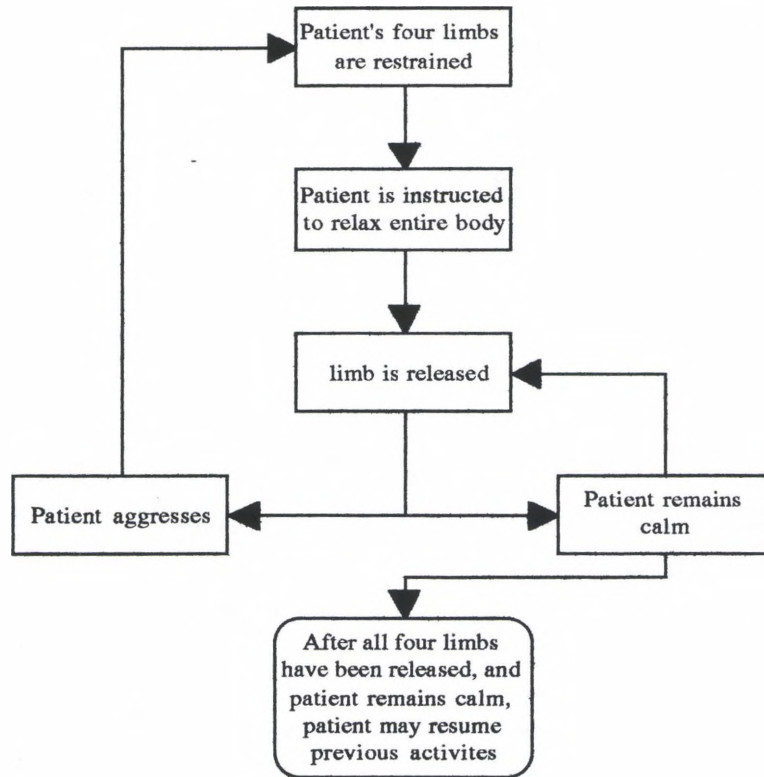


Figure 3. Flow chart depicting the steps of the progressive calming protocol.

be progressively released beginning with her left arm. If P. D. attempted to aggress during this time, staff would begin the entire protocol over. Once P. D. had successfully complied with the protocol's procedure, any previous interaction would resume.

C. T.'s behavior management plan, similar to P. D.'s, addressed various disordered behaviors. Likewise, the scope here will focus on his episodes of physical and verbal aggression (see Appendix G). A verbal outburst was defined as any verbalization made in anger at a volume above normal speaking tone. A physical outburst was defined as any threatening physical gesture made in anger toward a person out of arm's reach or an actual strike against an object including any imminent attempts within arm's reach or actual physical contact with another person in anger. This definition included finger pointing, fist shaking, or striking walls, tables, and other objects in anger.

C. T. was placed on 1:1 NBT coverage. When a verbal outburst occurred, staff would immediately cease all interaction with C. T. and ignore him until either of the following criteria were met: (a) 5 consecutive seconds of silence; (b) his resumption of a normal speaking tone and appropriate behavior without a 5-second delay.

When a physical outburst occurred, any current activity would cease and staff would implement a progressive calming protocol similar, in fashion to the one presented in P. D.'s case. If C. T. was about to throw an object, a verbal "stop" cue would be given if possible. If this failed and C. T. did throw the object, the calming protocol would be employed.

If the progressive calming protocol did not extinguish the physically aggressive behaviors within 15 minutes of initiation, the neurobehavior technicians would escort the patients to their beds and restrain each limb to the bed with cloth restraints. Chemical restraint was available if the patients did not calm within 30 minutes of being cloth-restrained to the bed. This mode of restraint was never utilized for either patient.

A post-discharge questionnaire was developed to assess the generalization of the behavior modification interventions following subject's discharge from the neurobehavioral program (see Appendix H). The questionnaire was administered to each subject's legal guardian and examined three different areas, behavioral, medical, and social.

The questionnaire explored the number of aggressive outbursts exhibited by each subject on a daily and weekly basis since their discharge. The type, duration, antecedent(s), and any particular patterns (e.g., specific time intervals) of the aggressive outbursts were queried. It was presumed that any changes in subjects' medical and social areas may affect their current behavior. Therefore, information regarding these factors was also taken.

The hospital's social workers maintain communication with their patients for a predetermined time following their discharge. Because of this, the subjects' social workers were chosen to administer the questionnaire. They were instructed to read the post-discharge questionnaire's statement of purpose, and then administer the questionnaire verbatim. The social workers were informed of the present study and the necessity of completing this questionnaire

verbatim. The neurobehavioral program supervisor read the questionnaire with each social worker prior to administration in order to clarify any questions the social workers might have had.

RESULTS

The purpose of the present study was to examine the efficacy of a specialized treatment program approach for decreasing aggressive behaviors in two frontal lobe damaged individuals. It was hypothesized that for both subjects the number of aggressive episodes would decrease following the implementation of a behavior modification plan. In addition, this decreased level of aggressive episodes was hypothesized to continue following their discharge from the program.

To examine these hypotheses, two separate analyses were utilized. First, the effects of the behavior modification procedures on the number of aggressive episodes exhibited during each subject's stay in the neurobehavioral program were assessed using a time series model. The rationale for using such a model rested in the notion that serial dependency is likely to exist in the data (Hartmann et al., 1980). Second, a post-discharge questionnaire was developed to assess each subject's behavior following his/her return to the community. The results of this questionnaire were then combined with the results of the statistical analyses to examine the treatment generalization of the behavior modification plan within other environmental contexts.

Time-Series Analysis: The ARIMA Model

The analysis of time-series data departs from classical measurement theory due to a unique component of the time-series data. This component has been termed serial dependency and refers to the notion that contiguous scores tend to be related to or predictive of one another (Jones, Vaught, & Russell, 1977). Hartmann et al. (1980) suggested

that serial dependency is likely to occur in operant research, such as the present study. When serial dependency is present in the data, it will most likely inflate the value of an inferential statistic by 300-400% (McDowall et al., 1980). Additionally, classical inferential statistical procedures (e.g., ANOVA) are inappropriate for the analysis of serially dependent data because serial dependency violates the statistical assumption of the independence of scores.

Considering these positions, the analysis of the data series in this study utilized the Auto Regressive Integrated Moving Average (ARIMA) model procedure. Suen and Ary (1989) describe the ARIMA model as a set of powerful techniques through which the effect of the serial dependency in a set of observations made over a period of time is assessed. The ARIMA model removes this effect and forecasts values that are then compared to the obtained values through the application of a direct difference t -test. The t -test allows for an evaluation of the impact of a behavioral intervention introduced at a particular time in the series.

The first step of the ARIMA procedure is to identify a particular model that best describes the pattern of the pre-intervention portion of the data. The ARIMA model consists of three parameters that denote the three possible models of the serial dependency in the data series. These parameters are the auto regressive (AR) function, the differencing (I) function, and the moving average (MA) function.

The auto regressive function describes the extent to which an observed value at time t is influenced by a function of previous observed values at time t_1, t_2, \dots, t_n . The order of the auto regressive process describes which preceding observed values affected the present observation. For example, in a first-order auto regressive process, an

observation is influenced by a function of the immediately preceding observed value only. A second-order process denotes the influence of the present observation by the two preceding observed values, and so on.

In a differencing function, an observed score is the sum of the immediately preceding score and random shock. Random shock is equivalent to random error in classical measurement theory (Suen & Ary, 1989). Differencing is important to the analysis since it reduces the nonstationarity of the series. Nonstationarity refers to the notion that within a time series, the auto regressive and moving average parameters change with time. It would be extremely difficult to identify a model to fit an ever-changing set of data. Therefore, it is necessary to transform the data to reach stationarity. This is accomplished by subtracting the immediately preceding observation from each observation. Differencing is calculated until the data displays signs of stationarity (Jones et al., 1977). Order of a differencing model reflects the number of times the time series must be transformed to reach stationarity.

A moving average function denotes the extent to which an observed score (x_t) at time t , is influenced by portions of the random shocks at times' $t - 1, t - 2, \dots, t - n$. This function is also described in terms of its orders. A first-order moving average model denotes that an observed score at time t is a function of the portion of random shock at time $t - 1$ only.

To describe all three parameters in a generalized manner, ARIMA models are expressed as ARIMA(p, d, q). The three terms within the parentheses represent the three parameters. Thus, p represents the auto regressive function, d represents the differencing function, and q represents the

moving average function. Values replace the variables in the parentheses depending on the order of each of the three parameters. For example, an ARIMA(1, 0, 1) model describes a process in which there is a first-order auto regressive function, no differencing function, and a first-order moving average function.

A vast number of possible models for any given set of time-series data can be produced by manipulating the values of p , d , and q . Fortunately, Glass et al. (1975) demonstrated that only 2% of a sample of time series in behavioral sciences required a second- or higher order auto regressive parameter, and few required higher order moving average parameters. McCain and McCleary (1979) reported that a mixed process (i.e., a process in which a combination of two or all three parameters exists) is a rare occurrence in behavioral observation studies. These research conclusions significantly reduce the number of specific models that need to be examined during this stage.

In addition, each ARIMA(p , d , q) model has its own distinctive statistical "signature" (Suen & Ary, 1989). These signatures are embedded within the autocorrelation function and the partial autocorrelation function of the time series. Since speculation of the most appropriate model would be an impossible task, the examination of these signatures provides guidance in the determination of the model. If a series does not conform precisely to a proposed model, subjective determinations are made and evaluated.

The autocorrelation function (ACF) is a set of Pearson product-moment correlation coefficients. Instead of representing the correlation between two variables, however, the ACF is the correlation of the same variable at two different times. The temporal distance between the two

observation points is referred to as the lag. If the computed ACF is the correlation between two observations made at contiguous points in time, the ACF is called a lag-1 ACF. Similarly, a lag-2 ACF is the correlation between observations made at time t and time $t + 2$. Theoretically, it is possible to compute a correlation between any two observations within the time series.

The lag- k partial autocorrelation function (PACF) is a correlation between an observation at time t and at time $t - k$ after the effects of the intermediate observations have been removed. The variable k refers to the width of the lag and is determined by the number of observations between t and $t - k$. The value of a PACF is a conditional correlation in that the value of the coefficient between the two observations is conditional to the values of the intermediate observations (Suen & Ary, 1989).

In the first step of model specification, it is necessary to calculate the lag-1 through lag- k ACFs and PACFs of the observed set of time-series data. A rule proposed by Hartmann et al. (1980) suggests that if there are N observations in the series, k should not be higher than $N/4$. The logic behind this rule is that the greater the lag, the more unstable the estimated values of the ACFs and PACFs. After the ACFs and PACFs are computed, their respective patterns are examined.

It is possible to determine a model for the time series on the basis of the patterns of these autocorrelation functions. A diagnostic check of the autocorrelations is performed to assess whether the pre-intervention data series significantly differs from a "white noise" model. This model is akin to random fluctuations in the data series (i.e., the null hypothesis). For the present study, if a

particular series was determined to consist of white noise data, the ARIMA analysis was considered not appropriate. A conventional statistical model (i.e., a t -test for independent samples) was then applied instead. To depart from the white noise model, the probability values of the autocorrelations must be statistically significantly at the $p < .05$ level.

Next, the data series containing serial dependency are fitted to a particular model. This is accomplished by estimating various parameters and measuring the proportion of these estimates that explain the pattern of the data series. A model is accepted when the autocorrelation check of the residuals of the estimates, or the proportion of the data that cannot be explained by the model, is assessed and the probability value of these residuals is not statistically significant ($p > .05$).

Once a model is identified and accepted, parameters, standard errors, and means are estimated in order to forecast values. Appendix I contains a graphical representation to supplement the description of these final ARIMA steps. Values are forecast for the post-intervention period from the data in the pre-intervention period. These forecasted values are then compared to the obtained values of the post-intervention period through a direct difference t -test. This analysis determines if the obtained values significantly deviate from what would have been expected. The sign of the t -value reflects the trend of the difference. A negative sign indicates that the obtained values were less than what would have been expected.

Descriptive Statistics

For the present study, the archival data of both subjects were grouped into three categories. These categories consisted of observed verbal, physical, and combined (i.e., verbal + physical) aggressive episodes recorded during 12-hour intervals (i.e., 12:00 a.m. to 12:00 p.m.; 12:00 p.m. to 12:00 a.m.) throughout each subject's length of stay in the neurobehavioral program (see Figures 4 & 5).

For both subjects, the mean number of aggressive episodes, standard deviations, and number of observations for each period (i.e., pre- and post-intervention) are shown in Table 1. For P. D., 150 observations were recorded, with the behavior modification plan implemented in the beginning of the 53rd observation interval. For C. T., a total of 278 observations was recorded, with the behavior modification intervention applied in the beginning of the 57th observation interval. As can be seen, there is a decrease in the mean number of aggressive episodes exhibited by both subjects from the pre-intervention to the post-intervention periods in all three aggression categories.

Behavioral Frequency Data

Subject 1: P. D. The autocorrelation checks for P. D.'s verbal ($p = .001$) and combined ($p = .001$) aggression categories significantly departed from the white noise model (see Table 2). This indicated that serial dependency exists in the data of both categories. For P. D.'s physical aggression episodes, the autocorrelation check determined that serial dependency was not present in the data

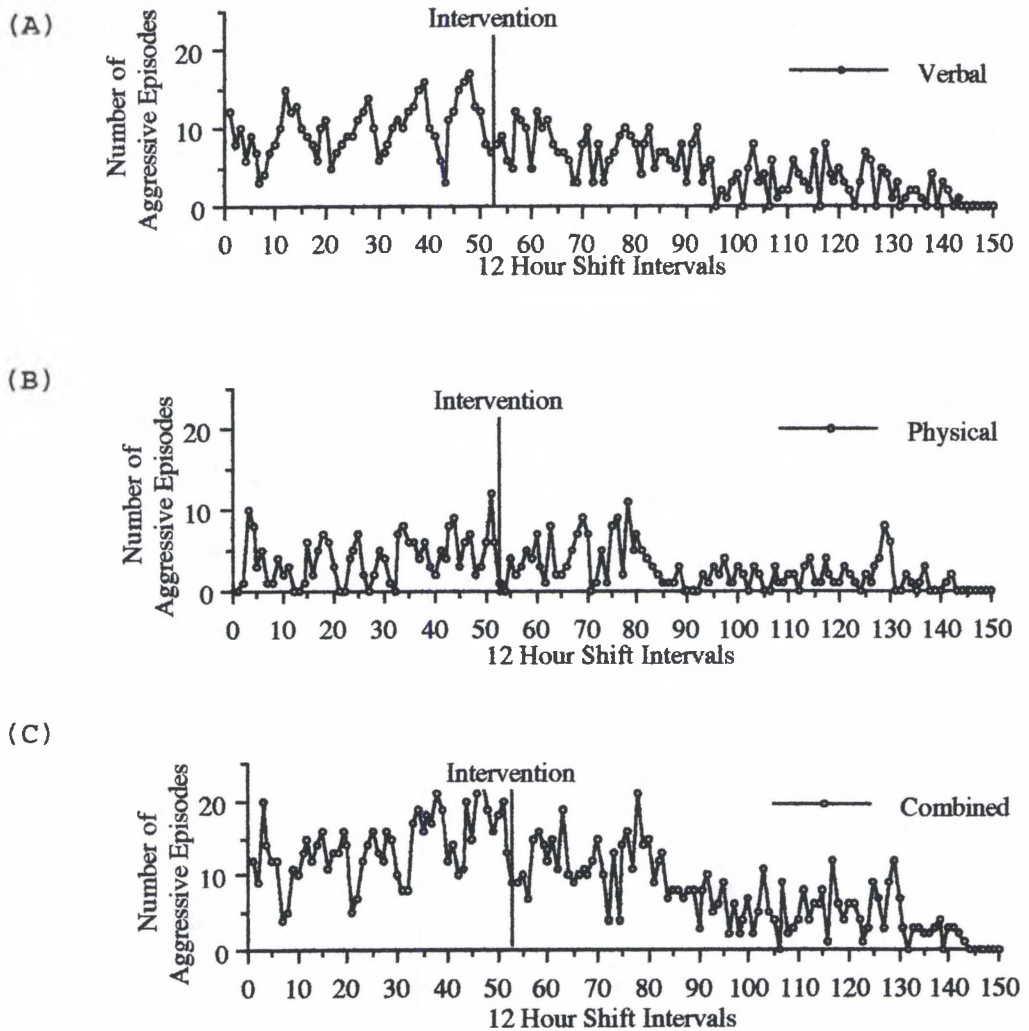


Figure 4. Data series for P. D.'s observed number of (A) verbal, (B) physical, and (C) combined aggressive episodes recorded during 12-hour intervals ($n = 150$) through her length of stay in the neurobehavioral program.

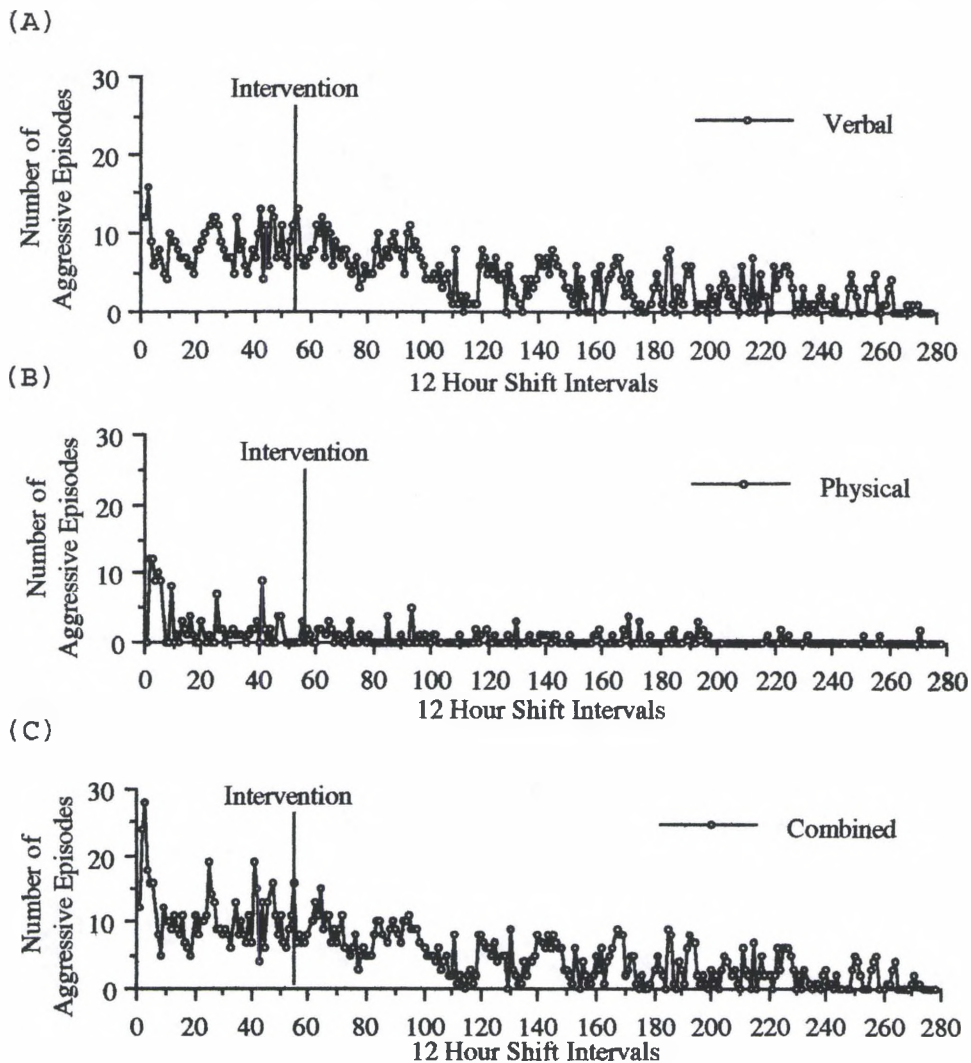


Figure 5. Data series for C. T.'s observed number of (A) verbal, (B) physical, and (C) combined aggressive episodes recorded during 12-hour intervals ($n = 278$) through his length of stay in the neurobehavioral program.

Table 1

Means and Standard Deviations of Data Series for Subjects' Aggression Categories Observed Prior to and Following the Introduction of the Behavior Modification Plan

Aggression Category	P. D.				C. T.			
	Pre-BMP		Post-BMP		Pre-BMP		Post-BMP	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
VERBAL	9.81	3.29	4.51	3.39	8.57	2.62	3.63	3.02
PHYSICAL	4.06	2.85	2.37	2.47	2.25	3.24	0.40	0.83
COMBINED	13.86	4.28	6.88	4.83	10.82	4.59	4.03	3.28

Note. "Pre-BMP" refers to observations recorded prior to the introduction of the behavior modification plan; "Post-BMP" refers to observations recorded following the introduction of the behavior modification plan.

Table 2

ARIMA Autocorrelation Check for White Noise: P. D. Series

Aggression

Category	To Lag	Chi Square	DF	Sig. of p
VERBAL	6	45.55	6	0.001
	12	61.08	12	0.001
PHYSICAL	6	08.81	6	0.184
	12	11.96	12	0.449
COMBINED	6	18.43	6	0.005
	12	32.33	12	0.001

Note. $p < .05$ indicates significant deviation from white noise.

($p = .449$). Thus, a t -test for independent samples was used to assess the impact of the intervention on P. D.'s physically aggressive behavior.

For both of the aggression categories that departed from a white noise model, a first-order auto regressive model (i.e., 1, 0, 0) was chosen to describe the serial dependency in the data (see Table 3). The estimated auto regressive parameter for P. D.'s verbal aggression category was 0.62, with a standard error of 0.11 and t ratio of 5.67 at lag-1. The estimated mean of the series was 9.79, with a standard error of 0.93 and t ratio of 10.54 at lag-0. For P. D.'s combined aggression series, the estimated auto regressive parameter was 0.50, with a standard error of 0.12 and t ratio of 4.12 at lag-1. The estimated mean of this series was 13.81, with a standard error of 1.02 and t ratio of 13.53 at lag-0.

Table 4 displays the results of the autocorrelation check for goodness-of-fit of the first-order auto regressive models for P. D.'s verbal and combined aggression categories. The first-order auto regressive (1, 0, 0) model was accepted ($p = .10$) for P. D.'s verbal aggression data series. Likewise, the first-order auto regressive (1, 0, 0) model was accepted for P. D.'s combined aggression series ($p = .27$). Forecasted values were then calculated. For the verbal aggression series, the forecasted values had a mean of 9.74 and a standard deviation of 0.22. The combined aggression forecasted values had a mean of 13.81 and a standard deviation of 0.05. The forecasted values were then compared to the obtained values through a direct difference t -test (see Figure 6). A significant difference between the forecasted and obtained values was found for P.D.'s verbal aggression series, $t(1, 97) = -14.95$, $p = .001$. Consistent

Table 3

ARIMA Parameter Estimation for a First-Order Auto Regressive Model for P. D.'s Data Series

Aggression

Category	Parameter	Estimate	Std. Error	t	Lag
VERBAL	mu	9.78933	0.92847	10.54	0
	AR	0.62352	0.11006	5.67	1
COMBINED	mu	13.81473	1.02139	13.53	0
	AR	0.50053	0.12138	4.12	1

Note. The approximate mean of data series is indicated by "mu."

Table 4

ARIMA Autocorrelation Check for Goodness-of-Fit of a First-Order Auto Regressive Model for P. D.'s Data Series

Aggression

Category	To Lag	Chi Square	DF	Sig. of p
VERBAL	6	10.71	5	0.06
	12	17.31	11	0.10
COMBINED	6	5.11	5	0.40
	12	13.42	11	0.27

Note. $p < .05$ indicates acceptance of proposed model.

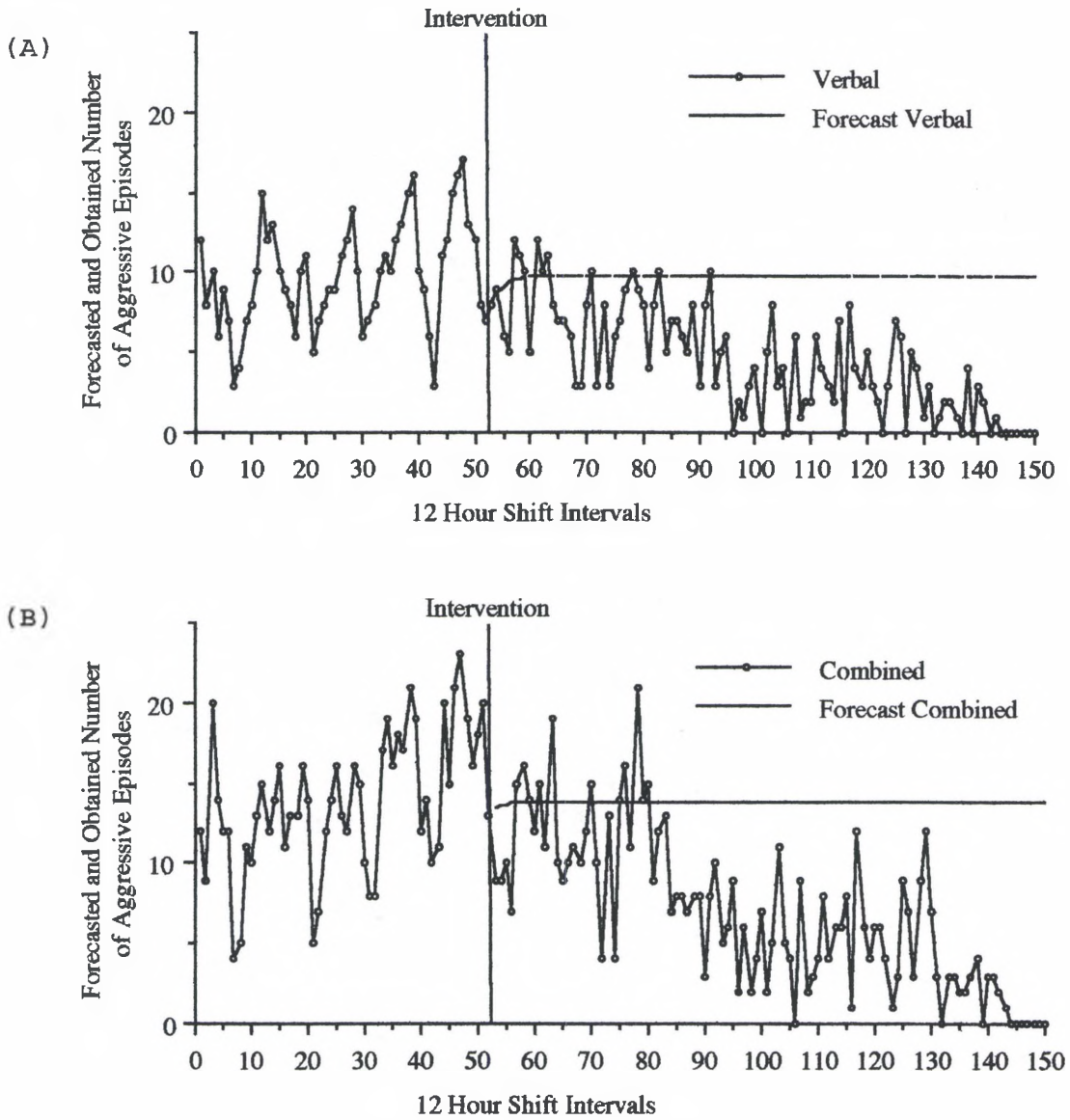


Figure 6. P. D.'s (A) verbal and (B) combined data series including forecasted values

with the hypothesis, the number of verbally aggressive episodes displayed by P. D. significantly decreased following the introduction of the behavior modification plan. In addition, a significant difference was found between the forecasted and obtained values for P. D.'s combined series, $t(1, 97) = -14.10$, $p = .001$. This indicated a significant decrease of overall aggressive behaviors following the introduction of the behavior modification plan, consistent with this present study's hypothesis.

A significant difference, $t(1, 148) = 3.79$, $p < .01$, was found between the pre- and post-intervention series for P. D.'s physical aggression category, utilizing the t -test for independent samples. Consistent with the present study's hypothesis, the number of physically aggressive episodes exhibited by P. D. decreased following the implementation of the behavior modification plan.

Subject 2: C. T. C. T.'s physical ($p = .008$) and combined ($p = .018$) aggression categories significantly departed from the white noise model, indicating the presence of serial dependency in the data (see Table 5). For C. T.'s verbal aggression series, the autocorrelation check determined the nonexistence of serial dependency in the data ($p = .499$). Therefore, for C. T.'s verbally aggressive behaviors, a t -test for independent samples was employed to determine the extent of the impact of the intervention.

For both of the aggression categories that departed from a white noise model, a first-order auto regressive model was chosen to describe the serial dependency in the data (see Table 6). The estimated auto regressive parameter for C. T.'s physical aggression category was 0.39, with a standard error of 0.12 and t ratio of 3.01 at lag-1. The

Table 5

ARIMA Autocorrelation Check for White Noise: C. T. Series

Aggression

Category	To Lag	Chi Square	DF	Sig. of p
VERBAL	6	8.95	6	0.176
	12	11.36	12	0.499
PHYSICAL	6	17.32	6	0.008
	12	19.78	12	0.071
COMBINED	6	15.34	6	0.018
	12	17.53	12	0.131

Note. $p < .05$ indicates significant deviation from white noise.

Table 6

ARIMA Parameter Estimation for a First-Order Auto Regressive Model for C. T.'s Data Series

Aggression

Category	Parameter	Estimate	Std. Error	t	Lag
PHYSICAL	mu	2.19917	0.65759	3.34	0
	AR	0.39292	0.12518	3.14	1
COMBINED	mu	10.78846	0.95747	11.27	0
	AR	0.41732	0.12395	3.37	1

Note. The approximate mean of data series is indicated by "mu."

estimated mean of this series was 2.20, with a standard error of 0.66 and t ratio of 3.34 at lag-0. The estimated autoregressive parameter was 0.41, with a standard error of 0.12 and t ratio of 3.37 at lag-1 for C. T.'s combined aggression category. The estimated mean of the series was 10.79, with a standard error of 0.96 and t ratio of 11.27 at lag-0.

The results of the autocorrelation check for goodness-of-fit for first-order autoregressive models of C. T.'s aggression categories are shown in Table 7. For C. T.'s physical aggression data series, the first-order autoregressive model (1, 0, 0) was accepted ($p = .603$). The first-order autoregressive model (1, 0, 0) was also accepted for C. T.'s combined series ($p = .875$).

Forecasted values were then calculated. C. T.'s physical aggression forecasted values had a mean of 8.19 and a standard deviation of 0.06. The combined aggression forecasted values for C. T. had a mean of 10.78 and a standard deviation of 0.12. The forecasted values were then compared to the obtained values through a direct difference t -test (see Figure 7). A significant difference was found for C. T.'s physical aggression series, $t(1, 221) = -31.75$, $p = .001$. Consistent with the hypothesis, the number of physically aggressive episodes displayed by C. T. significantly decreased following the introduction of the behavior modification plan. In addition, a significant difference was found between the forecasted and obtained values for C. T.'s combined series, $t(1, 221) = -30.41$, $p = .001$. This indicated that a significant decrease of overall aggressive behaviors occurred following the introduction of the behavior modification plan, consistent with this present study's hypothesis.

Table 7

ARIMA Autocorrelation Check for Goodness-of-Fit of a First-Order Auto Regressive Model for C. T.'s Data Series

Aggression

Category	To Lag	Chi Square	DF	Sig. of p
PHYSICAL	6	3.64	5	0.60
	12	10.07	11	0.52
COMBINED	6	3.36	5	0.64
	12	5.19	11	0.92

Note. $p < .05$ indicates acceptance of proposed model.

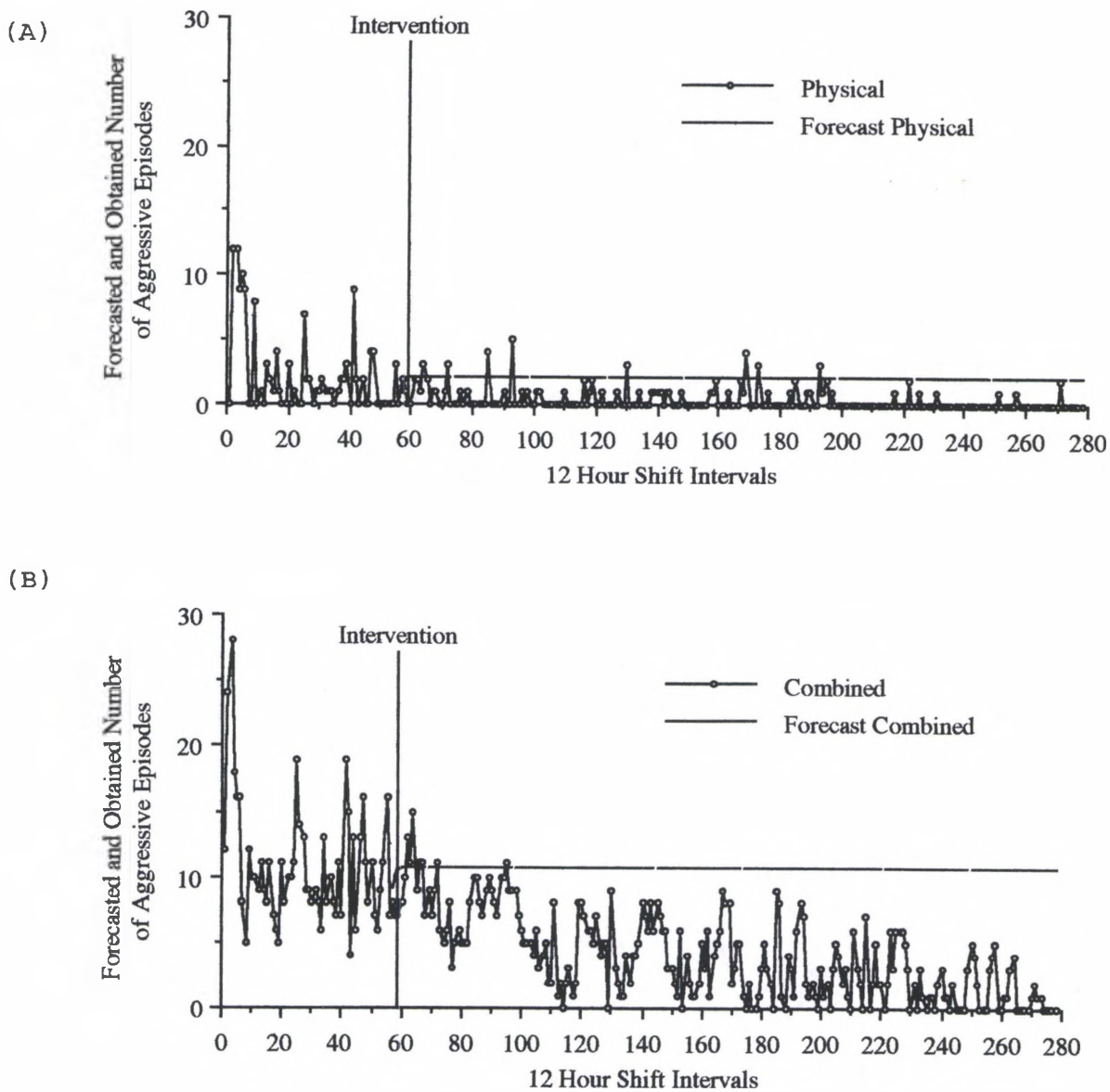


Figure 7. C. T.'s (A) physical and (B) combined data series including forecasted values.

Results of the t -test for independent samples indicated a significant difference between the pre- and post-intervention series, for C.T.'s verbal aggression category, $t(1, 276) = 11.09, p < .01$, supporting this study's hypothesis. The occurrence of verbally aggressive episodes for C. T. decreased following the implementation of the behavior modification plan.

Post-Discharge Questionnaire

Subject 1: P. D. The post-discharge questionnaire was completed on June 30, 1993, approximately 5 months after P. D.'s discharge from the neurobehavior program. At this time, P. D. is living at home with her family. She exhibits approximately three verbal outbursts per week, and zero physical outbursts. There has been no change indicated in the characteristics of the outbursts. A typical verbal outburst is about 3 minutes in duration. The family attempts to ignore the episode. P. D. will calm herself and then attempt to process the episode. Finances and the children are particular antecedents to verbal outbursts.

P. D. is attending outpatient neuropsychological services once per week for 60 minutes per session. Aggressive episodes do not occur during such sessions. A behavior management plan for use in the home has been developed, targeting verbally aggressive behavior. However, no description of this plan was available. P. D. and her therapist are currently working on recognizing aggressive comments and rephrasing them. Medically, abnormal EEG patterns continue. P. D. is remaining on medication, which consists of 200 mg Tegretol BID, and 50 mg Asendin BID. Tegretol has been prescribed for seizure and behavior control, while the Asendin stabilizes her mood.

During the past 5 months, P. D. has become increasingly involved with her family and family functioning. The family has a loosely established schedule of chores and leisure.

Subject 2: C. T. The post-discharge questionnaire was completed on June 30, 1992, approximately 3 months following C. T.'s discharge from the neurobehavior program. Currently, C. T. is living in his home with his wife and son. His wife reported that C. T. experiences approximately one verbal outburst every 10- to 12 days. C. T. has not displayed any physically aggressive behaviors since being discharged from the neurobehavior program. There has been no change in the characteristics of the verbal episodes. The typical duration is 2- to 3 minutes. It was reported that family members were using calming techniques. C. T. was reported to be most irritable in the morning, and when certain topics arise in discussions. He is more times than not apologetic for his behavior after it has occurred.

C. T. is presently receiving counseling once per month. No episodes are reported to occur during these sessions. A behavior management plan has not been developed by C. T. and his current counselor. They are working on adjustment and daily living issues.

No medical examinations have been administered since C. T.'s discharge. However, a neuropsychological reevaluation is scheduled for the middle of July. He is currently not taking any prescribed medication. Socially, C. T. has a daily routine that consists of independent meal preparation, and maintenance of yard, house, and pool. He also enjoys walking. Vocational treatment is being considered.

In summary, first-order auto regressive ARIMA models were fit and accepted for the pre-intervention phases of four of the six aggression categories between both subjects. These were P. D.'s verbal and combined, and C. T.'s physical and combined categories. For the remaining data series, P. D.'s physical and C. T.'s verbal, white noise models were fit and accepted as appropriate.

After these ARIMA models were determined, values were forecast for the four first-order auto regressive models. The forecasted values for the post-intervention phase were then compared to the obtained values through a direct difference t -test. The remaining two time series were subjected to a t -test for independent samples, using the pre-intervention phase as one sample and the post-intervention phase as another. Results of these analyses indicated significant decreases in all three aggression categories for both subjects.

A post-discharge questionnaire was developed and administered to both subjects. This questionnaire examined the status of each subject following his/her discharge from the neurobehavioral program. It was found that both subjects rarely displayed physically aggressive behaviors and only occasionally exhibited verbally aggressive behaviors since discharge.

DISCUSSION

The number of traumatic head injuries in the United States has increased dramatically within the past 10 years. A nationally estimated number of one to two million persons currently suffer from some form of head injury (Dahl, 1993). To meet the rising needs of this population, the number of hospitals specialized for the rehabilitation of this population has increased exponentially within the past 12 years (Committee on Government Operations, 1992). Significant advances have also been made in the medical care of such individuals (Wood & Eames, 1989). However, Mateer and Ruff (1990) have observed that behavior disorders, which are quite common following traumatic head injury, have received much less attention and are not included in many currently established treatment regimens.

Behavioral rehabilitation focuses on those behaviors that are likely to impede an individual's ability to function adaptively and that adversely affect other areas of rehabilitation (Lezak, 1983). Such behaviors may include decreased attention, motivation, and motor control, as well as increased aggression. Mattson and Levin (1990) have noted that increased aggressive behavior commonly presents following frontal lobe damage. These authors have suggested that it is imperative to explore treatment programs that will effectively increase the rehabilitation potential of patients with frontal lobe damage who present with aggressive behavior.

One treatment intervention that has been successful with a wide variety of psychological and organic disorders is behavior modification (Kazdin, 1980). The use of behavior

modification with the brain injured population is sparsely documented, and only a small amount of literature is available, mostly in the form of single case designs. Nonetheless, it appears that the use of this intervention in the rehabilitation of the head injured population has experienced some success (Burke & Lewis, 1986; Eames, 1988; McGlynn, 1990; Wood, 1984).

The present study examined the effectiveness of a behavior modification based neurobehavioral rehabilitation program for decreasing the number of verbally and physically aggressive behaviors exhibited by two individuals with frontal lobe damage. It also attempted to explore the generalization effects of this treatment approach by investigating the progress of both clients following their discharges from the neurobehavioral program. For the purposes of the present study, treatment efficacy was defined through two perspectives. First, treatment was determined to be effective if a statistically significant decrease in the number of aggressive episodes occurred during each subject's length of stay in the neurobehavioral program. Second, treatment was deemed effective if the decreased number of aggressive episodes persisted following each subject's discharge from the neurobehavioral program.

Treatment Efficacy I: Patient Progress Through the Neurobehavioral Program

The results of the data analyses conducted indicated that a statistically significant decrease in the number of verbally, physically, and combined aggressive behaviors occurred for both subjects following the introduction of the behavior modification plans. Both subjects displayed substantially fewer aggressive episodes, regardless of type,

subsequent to the implementation of the behavior modification plans. These results support the present study's hypothesis and lend credence to the effectiveness of behavior modification in reducing aggressive episodes displayed by frontal lobe damaged individuals.

The neurobehavioral program is located in a secure wing of the rehabilitation hospital and a substantial amount of environmental control is possible within it. During both subjects' lengths of stay, the implementation of the verbal and progressive calming protocols (i.e., behavior modification plans) was the only environmental change that occurred. All other scheduled activities, such as the rehabilitation therapies, meal times, and medication times, were delivered at the same time every day. Since the administration of the behavior modification treatment was the only environmental influence to change dependent upon each subjects' behavior, it can be viewed as contributing to, at least in part, the observed changes in aggressive behaviors.

Serial dependency was detected in four of the six aggression categories. These were P. D.'s verbal and C. T.'s physical, and both subjects' combined aggression data series. A first-order auto regressive function was fit and accepted for these series. The remaining two data series did not exhibit signs of serial dependency. An important implication can be made from the occurrence of serial dependency in these data series. Following from ARIMA analysis theory (McDowall et al., 1980), if inferential statistics were employed in this study, the existence of serial dependency would likely have confounded the results by potentially inflating the obtained values. The ARIMA analysis, however, proved to be useful in the present study by detecting and controlling for such effects. Since serial dependency has been observed to

frequently occur in time series data (Suen & Ary, 1989), it appears to be valuable statistical procedure to be used in designs similar to the present study.

Treatment Efficacy II: Patient Status Post-Discharge

As McGlynn (1990) has observed, "if the behaviors and skills acquired through rehabilitation cannot be maintained in the real world, then the treatment program has ultimately failed" (p. 437). Generalization of treatment effect has long been a concern for psychologists who have employed behavioral methods. Corsini and Wedding (1989) refer to generalization as the occurrence of behaviors in situations that resemble, but is different from, the stimulus environment in which the behavior was learned. For this study, if the learned treatment effect (i.e., decreased aggressive behavior) is generalized to the subjects' community environments, then the interventions gain stronger credibility as being successful.

For both subjects, it appeared that the number of aggressive episodes continued to decrease in occurrence per day for some time following discharge, at which time they stabilized. Currently, both subjects display verbally aggressive episodes about once or twice a week, and episodes of physical aggression are rare. This persistent decrease in the number of aggressive episodes per day, what appears to be a carry-over effect, lends support to the present study's second hypothesis. It also further strengthens one's confidence in the treatment efficacy of the neurobehavioral program.

Since there are a significant number of factors that may have contributed to the noted behavior change, it was necessary to explore such factors. The post-discharge

questionnaire was developed to examine the various behavioral, medical, and social factors that may have facilitated this continued effect.

The families of both subjects reported monitoring and responding to the occurrence of aggressive episodes. Both subjects have been receiving rehabilitation counseling since discharge. P. D.'s sessions are focusing on verbal aggression and appropriate alternatives to express such feelings, and C. T.'s are centered on adjusting to daily living.

The results of the questionnaire revealed that there have been no significant changes in the medical conditions of either subject. For P. D., results of a recently administered EEG indicated similar brain wave patterns as when she was a patient in the neurobehavioral program. Since C. T. is scheduled for a similar examination in the future, this information was not available at this time. There have been no medication changes for P. D., and C. T. is currently not being prescribed medication. The probability of changes in cerebral activity and/or medication sustaining this decreased occurrence of aggressive episodes is low.

Besides counseling that began immediately following discharge, the only changes that have occurred for both subjects are their new environments and the termination of the behavior modification plans. Given these observations, both subjects appear to be maintaining the behaviors and skills that they acquired in the neurobehavioral program. Thus, the continued decrease in aggressive behaviors following discharge appears to be a generalization effect of the treatment to other environments.

Strengths, Limitations, and Conclusions

In the present study, the SSED allowed for clear descriptions of extra-experimental characteristics to be delineated and included in the analyses. This design also allowed for the evaluation of an intervention across a given interval, which potentially controlled for spontaneous recovery effects by examining data as they were recorded.

The use of the SSED in the present study facilitated a complete presentation of demographic information and greater reliability concerning the effects of treatment. Aeschleman (1991) noted that single-subject designs control for variability from sources other than the treatment at the level of the individual. Thus, more reliable inferences relating treatment to individuals are generated. Aeschleman continues, suggesting that for certain areas of psychology such as rehabilitation, which are primarily concerned with identifying variables that have functional utility at the level of individual clients, the single-subject design offers more external validity. Kazdin (1981b) has suggested that single-case experimental designs are just as effective as traditional between-group approaches in controlling for potential confounding.

The design of the present study also permitted each subject to receive treatment. Single-subject experimental designs are typically in accord with clinical ethics and goals. It is usually the timing of treatment onset, not the provision of treatment, which is varied. Treatment is not withdrawn or excluded from clients, as can be the case with group designs (Gianutsos & Gianutsos, 1987). The nature of single-subject experimental designs are quite compatible with the rehabilitation philosophy of individual-specific care and treatment. In the present study, treatment of each subject

was tailored to their specific needs, yet was able to be subsumed under a generic construct (i.e., aggressive behavior).

The ARIMA model had significant utility in the present study. Because the ARIMA model can detect the existence of serial dependency in data series, it can avoid potential confounding caused by the inflation of serial dependency on inferential statistics. This leads to a more accurate reporting of obtained results.

The major limitation of the present study is that it was not developed from a strict ABA experimental design; subjects did not return to a baseline phase during their length of stay in the neurobehavioral program. Because of this, it is more difficult to conclude that both subjects' sustained decreased number of aggressive episodes following their discharges is a direct effect of the treatment they received in the neurobehavioral program.

The post-discharge questionnaire, administered to family members, attempted to minimize this limitation by examining both subjects' behavior following their discharges. The administration of this questionnaire to such individuals, however, can lead to potentially biased conclusions because of the involvement of the family in patient rehabilitation. The questionnaire lacked controlled observations of independent raters. Future research should focus on the development of more objective observation recordings following patient discharge from treatment programs.

The ARIMA analysis is limited by the somewhat subjective manner in which it fits models into the data series. For untrained evaluators, the identification of appropriate models is difficult. Research has indicated that only a small percentage of time series will require second- or

higher-order auto regressive models (Glass et al., 1975). Additionally, McCain and McCleary (1979) have suggested that mixed processes are rare occurrences in behavioral studies. Nonetheless, this study was fraught with ARIMA model identification dilemmas. For the models that were not identified as white noise, three of the four could have been fit to either first-order auto regressive or moving average models. Both of these models yielded significant autocorrelations for the data series. However, since it was determined that the auto regressive models exhibited a higher level of significance than the moving average models, they were chosen.

Given the heterogeneity of lesion sites and their effects on individuals suffering from head injuries, the SSED and ARIMA model appear to be logical choices in the analyses of treatment effectiveness. They allow the clinician/researcher to examine individual cases in more relevant fashions, to present fuller individual descriptions, and to observe potential patterns in the data.

For both dimensions of treatment efficacy defined in the present study, the neurobehavioral program met the criteria. This treatment program, based on behavior modification principles, was effective in reducing aggressive behaviors exhibited by the subjects in this study. Not only did these behaviors decrease during treatment, they continued to decrease following treatment and eventually stabilized at very low occurrence rates. The results of this study open a path to a variety of future research endeavors, all of which have potential implications for the specialist in head trauma rehabilitation. Several directions for future research can be given.

A stronger focus must be placed on the behavior of head injured individuals following their discharge from behavioral rehabilitation programs. The present study was more concerned with inpatient treatment efficacy and its accompanying experimental design and statistical analyses. Developing valid measures that can be administered following individuals' discharge to monitor and track their progress may yield significant insights into the long-term effects of behavior modification treatment techniques with the head injured population. It would be appropriate to conduct longitudinal studies focusing on initial presenting disordered behavior and tracking its occurrences for some time following discharge from a behavioral rehabilitation program.

Continued investigations of behavior modification based neurological rehabilitation programs for behavior disorders must be conducted to increase the validity of behavior modification as a viable treatment option in the successful rehabilitation of head injured individuals. Aggression is far from the only type of behavior that may impede rehabilitation progress. Initial research applying behavior modification techniques to other types of disordered behavior following head injury has seen success (McGlynn, 1990).

Research also must be conducted concerning the effects of behavior modification procedures on individuals displaying aggressive behavior who have non-frontal brain damage. Lesions in different cortical areas may produce varied reactions to such techniques. It is quite possible that damage to certain areas of the cortex will inhibit the ability of the head injured individual to benefit from behavior modification techniques. Behavior modification is

be considered a learning technique, and if damage to certain learning centers of the brain occurs, behavioral techniques may prove to be futile.

Finally, it is of interest to determine the best time for a behavior program to be phased out. This may avoid placing undue stress on the staff, patients, and financial parties involved. Working with patients who display aggressive or similarly disordered behaviors increase the stress experienced by staff (Dunn et al., 1992). Additionally, with a health care crisis occurring in this country, it is imperative to provide effective, yet time constrained, treatment. Determining a period in which the clinician can safely deem that treatment has been successful and should be withdrawn may significantly reduce the stress levels of staff, as well as reduce unnecessary inpatient costs.

McGlynn (1990) is optimistic regarding the role of behavior modification in rehabilitating the head injured population. The present study demonstrated that behavior modification techniques, administered in a structured environment, decreased aggressive behaviors in two frontal lobe damaged individuals. This decreased display of aggressive episodes continued after both subjects were discharged from the program. Although this study does not generalize to the successful use of such a treatment paradigm with the head injured population at large, it adds to existing research and yields pertinent concerns, information, and suggestions for future research endeavors for the head trauma rehabilitation specialist.

APPENDICES

APPENDIX A

NEUROBEHAVIORAL PROGRAM BEHAVIOR
OBSERVATION FORM

APPENDIX B

RANCHOS LOS AMIGOS SCALE
OF COGNITIVE FUNCTIONING

Ranchos Los Amigos Scale of Cognitive FunctioningLevel I: No Response

1. Complete absence of observable changes in behavior when presented with visual, auditory or noxious stimuli.

Level II: Generalized Response

1. Demonstrates generalized reflex response to noxious stimuli.
2. Responds to repeated auditory stimuli with increased or decreased activity.
3. Responds to external stimuli with physiological changes.

Level III: Localized Response

1. Demonstrates withdrawal or vocalization to noxious stimuli.
2. Turns toward or away from auditory stimuli.
3. Blinks when strong light crosses visual field.
4. Follows moving object passed within visual field.
5. Responds to discomfort by pulling tubes or restraints.
6. Responds inconsistently to simple commands.

Level IV: Confused-Agitated

1. Alert and in heightened state of activity, but demonstrates severely decreased ability to process environment. Responds primarily to own internal agitation.
2. Performs motor activities but behavior is essentially non-purposeful relative to environment.
3. Demonstrates aggressive or bizarre behavior.

Level V: Confused-Inappropriate-Non-Agitated

1. Alert, demonstrates gross attention but difficulty maintaining selective attention.
2. Demonstrates severe impairment of memory functions.
3. Responses are fragmented and frequently inappropriate to the situation, reflecting confusion and lack of goal-direction.
4. Demonstrates agitation in response to external stimuli.
5. Wanders from treatment areas.
6. Absent carryover for purposes of learning; assisted to maximally supervised in activities.

Level VI: Confused-Appropriate

1. Inconsistently oriented to time and place; recent memory is impaired with decreased detail and depth of recall.
2. Follows simple directions consistently; responses are appropriate but may be incorrect if requiring new memory.

3. Supervised for new learning with little or no carryover but shows carryover for previously learned skills.
4. Actively participates in therapy programs and demonstrates some purposeful behavior but remains dependent on external structure.

Level VII: Automatic-Appropriate

1. Appropriate and oriented within hospital-home settings.
2. Able to go through daily routine with minimal to absent confusion; depth of recall may be shallow, however.
3. Demonstrates carryover for new learning although at a decreased rate; requires at least minimal supervision for learning and for purposes of safety.
4. Demonstrates superficial insight into disabilities, decreased judgment and abstract reasoning; lacks realistic planning for own future. Prevocational evaluation and counseling may be indicated.

Level VIII: Purposeful-Appropriate

1. Alert, oriented; intact recall for past and recent events.
2. Demonstrates carryover for new learning; functions independently, within physical capabilities, once new tasks are learned.
3. Able to formulate realistic goals for own future; may be candidate for vocational rehabilitation.
4. Able to apply adequate judgment to daily living and community situations relative to pre-injury ability level.

APPENDIX C

RELEASE OF INFORMATION FORM

TREATMENT EFFICACY OF A NEUROBEHAVIORAL REHABILITATION
PROGRAM FOR DECREASING AGGRESSIVE BEHAVIORS EXHIBITED BY TWO
INDIVIDUALS WITH FRONTAL LOBE DAMAGE

B. Scott Baxter
University of Dayton

Statement of Purpose

As partial fulfillment of the requirements for the degree of Master of Arts in Psychology at the University of Dayton, I am required to complete an approved, independent research project. I have chosen as this project to assess the ability of the neurobehavioral program to decrease verbally and physically aggressive behaviors in certain types of head-injured individuals.

Specifically, the purpose of this study is to evaluate the behavior modification plan developed and implemented by the staff of the neurobehavior program to decrease these aggressive behaviors displayed by the patient. It will also assess the longer-term effects of the program, once the patient was discharged from the program. The hypotheses of this study are that the behavior modification plans will decrease the types of behavior mentioned above and this decrease will continue following their discharge.

In order for me to complete my objectives, I will need to examine the behavioral frequency data of two (2) subjects who have been discharged from the program. Your family member has met all of the criterion for inclusion into this study. I would ask that you permit me to examine their progress through the program and following discharge by signing the accompanying release of information from.

I must inform you that I will be mentioning demographic information also in my thesis, so as to complement the behavioral data, as well as detailing the scope of the project. The ethical code of psychologists requires that the

description of research subject's demographic information, performance on tests, etc. must be held in confidence. The information in this study, therefore, will be presented in such a way so as to protect your family member's right to privacy.

If you have any questions or concerns, please do not hesitate to contact David Johnson at the neurobehavioral program, or myself at (513) 439-4226.

CONSENT FOR RELEASE OF INFORMATION

I hereby authorize _____ to release
Health Care Facility

information from the records of _____
Patient's Name Birthdate

Address

The information is to be released to _____
Person or Organization

Address

for the purpose of _____

Information to be released is (itemized portions/time periods)

I also understand that this consent will remain in force for the duration of the patient's inpatient stay and will become null and void following discharge. I understand that this consent may be revoked by me at anytime by submitting written requests to do so.

Patient Date

Guardian, Next of Kin or Sponsoring Agent Date

Witness Date

MEDICAL RECORDS REQUEST

- _____ A. INPATIENT RECORDS (as checked below)
 _____ B. OUTPATIENT\ANCILLARY RECORDS (as checked below)
 _____ 1. Physician's Orders
 _____ 2. History and Physical (signed by physician)
 _____ 3. Physical Medicine & Rehabilitation Evaluation
 (PM&R)
 _____ 4. Neurological Assessment
 _____ 5. Progress Notes
 _____ 6. Graphic Sheets (vital signs)
 _____ 7. Nurses' Notes
 _____ 8. Medication Records
 _____ 9. Discharge Summary
 _____ 10. Monthly Summaries
 _____ 11. Social Service Record
 _____ 12. Emergency Room/Treatment Room Reports
 _____ 13. Outpatient Visit Report
 _____ 14. Pathology Reports
 _____ 15. Operating Room and Anesthesia Reports
 _____ 16. Laboratory Report (s)
 _____ CBC
 _____ Urinalysis*
 _____ Serology*
 _____ Most recent culture and sensitivity for any
 open areas. *(Preferably within last 60 days).
 _____ 17. X-ray Reports
 _____ Chest X-ray within last 60 days
 _____ 18. All EEG and Evoked Potential Reports
 _____ 19. All CT Scan Reports
 _____ 20. Last two CT Scan Films
 _____ 21. Therapy Evaluation, Progress Notes and Discharge
 Summaries
 _____ Psychology
 _____ Physical Therapy
 _____ Speech/Language Pathology
 _____ Therapeutic Recreation
 _____ Occupational Therapy
 _____ Respiratory Therapy
 _____ 22. Vocational Assessment
 _____ 23. Multidisciplinary Team Reports
 _____ 24. Consultations
 _____ 25. Other: _____

A copy of this form is to be returned with all reports/records

Date Sent _____ Date Received _____

APPENDIX D

DEMOGRAPHIC INFORMATION: P. D.

Name: P. D. Gender: Female
 Age: 30 Race: Caucasian
 Marital Status: Married Education: HS Graduate
 Handedness: Right Ranchos Scale: IV

Onset: May 12, 1992
 Length of Coma: Nine Days
 Length of PTA: Three to four Months (P.D.'s estimate)
 Admit: November, 16, 1992
 Discharge: January 29, 1993
 Length of Stay: 74 Days

Admitting Diagnosis: Depressed, comminuted skull fracture; left frontoparietal laceration; bilateral frontal lobe atrophy.

Presenting Problem(s): Behavioral dyscontrol; aggressive outbursts; emotional lability; lack of insight.

Past Medical History: Hysterectomy; one pack a day smoker for 12 years; no history of seizures. Upon admission to the neurobehavioral program, P. D. had been prescribed Colace 100 mg BID, Tegretol 200 mg BID, Buspar 10 mg QID, Ativan 0.5 mg HS and Multivitamins Daily. This prescription regimen continued throughout her stay in the program.

Physical Assessment: P. D. was involved in a motor vehicle accident on May 12, 1992. Underwent left frontal craniectomy immediately following accident. EEG reports identified some diffuse nonspecific encephalopathy with focal left frontal laceration and bifrontal atrophy. CT scans, five during first four weeks following injury, revealed minimal diffuse, permanent damage. P. D. displayed slight left hemiparesis. She was unresponsive to noxious stimulants until 5/17 and began to make purposeful movements on 5/21. She was in acute rehabilitation for two months following the incident. At time of admittance to the neurobehavioral program, she had been residing with her mother-in-law. Her aggressive behavior had become unmanageable for her mother-in-law to provide adequate care.

Psychosocial History: P. D. has been married for approximately eight years. From this marriage, she and her husband have three children. Prior to her accident, she worked as a part-time employee at a manufacturing plant. Reports from family indicated that prior to her accident, P. D. was a self-reliant, affectionate mother and wife. No history of psychopathological, aggressive, or criminal behavior was noted.

Relevant Testing: Results of psychometric assessment indicated an IQ within normal parameters; moderate impairment of verbal/language skills; severe impairments in memory; poor attention. Overall, P. D.'s cognitive skills have been significantly compromised for most nonverbal activities and most areas of memory.

APPENDIX E

DEMOGRAPHIC INFORMATION: C. T.

Name: C. T. Gender: Male
Age: 43 Race: Caucasian
Marital Status: Married Education: 2 yr. College
Handedness: Left Ranchos Scale: IV

Onset: February 10, 1992
Length of Coma: Unable to verify from existing records;
Was noted to open eyes 13 days following
incident
Length of PTA: Five weeks
Admit: September 30, 1992
Discharge: March 19, 1993
Length of Stay: 171 Days

Admitting Diagnosis: Left frontoparietal
intraventricular/intraparenchymal hemorrhage;
bifrontal contusion; subdural hematoma; marked cortical and
central frontal atrophy with compatible ventricular
dilation.

Presenting Problem(s): Agitation - swears, spits, hits,
kicks; emotional lability; short attention span; decreased
frustration tolerance, disorientation to time and place;
decreased short term memory.

Past Medical History: unremarkable except for small hiatal
hernia and recurrent right ear infections; one-half pack a
day smoker. Upon admission to the program, C. T. had been
prescribed Colace 100 mg BID, Naprosyn 500 mg BID, Benadryl
25 mg HS, and Ativan 1 mg HS.

Physical Assessment: On February 10, 1992, C. T. was
involved in a motor vehicle accident. CT scans revealed
cortical atrophy in the frontal cortex as well ventricular
dilation. He was admitted to an acute care rehabilitation
facility approximately two months later, following medical
stabilization of post-traumatic encephalopathy. He was
referred to the neurobehavior program because of increasing
physical outbursts which caused severe disruption of his and
other patient's rehabilitation progress at the acute
facility.

Psychosocial History: C. T. has been married for
approximately twenty-two years. From this marriage, he and
his wife have two children. Prior to his accident, C. T. was
a retired warrant officer in the U.S. Navy, serving for
approximately 22 years. Reports indicated that C.T. has
been a loyal father and husband. He was described by his wife
as "always on the go." He was also reported having a low
frustration tolerance, and would become depressed and
withdrawn when this threshold was reached. No history of
marital problems and denied history of abuse. No incidents
of psychopathological, aggressive, or criminal behavior were
noted.

Relevant Testing: Results of psychometric assessment indicated an IQ slightly below average; marked impairment of verbal/language skills; severe impairments in memory; marked impairments in selective attention. LNNB-II impairment index of 4. Overall, C. T.'s cognitive skills have been grossly hindered in the areas of nonverbal activities and most areas of memory and attention.

APPENDIX F

BEHAVIOR MANAGEMENT PLAN: P. D.

Name: P. D. Gender: Female
 Age: 30 Race: Caucasian
 Marital Status: Married Education: HS Graduate
 Handedness: Right Ranchos Scale: IV

Presenting Problem(s): Aggressive outbursts

Target Behaviors: Verbal Outburst: any statement made in an angered tone, above normal speaking volume; any statement or gesture of expressed physical harm to another person, usually stated in a heightened state of anger. Physical Outburst: actual physical contact with inanimate objects; attempt to make contact, or actual contact, with another person in anger.

Interventions: Verbal Outburst:
 Provide P. D. with 'stop' cue, raising hand gently, with palm of hand facing P. D.;
 State flatly, in non-authoritative fashion: "P. D., stop, you are sounding very angry. Take two deep breaths and count to ten slowly;"
 Note success with procedure and offer verbal praise if P. D. calms;
 If calms, offer suggestion for the source of her anger and suggest how she could otherwise express herself;
 If does not calm, turn away from her, removing eye contact;
 Monitor ability to deescalate; as she calms, count to ten slowly and return attention to her.
 Physical Outburst:
 Offer one verbal 'stop' cue, prior to outburst if possible;
 Implement progressive calming protocol.

Data Type: Record number of outbursts as they occur, describing antecedents and reactions to consequences, as well as duration of the outbursts and restraints, if implemented. During periods of calm, remark on patient status every fifteen minutes.

Miscellaneous Information: PRN medication is available (Haldol 10 mg IM). If P. D. does not calm within one-half hour of being placed in cloth restraints, attending physician is to be notified and he/she will prescribe medication.

APPENDIX G

BEHAVIOR MANAGEMENT PLAN: C. T.

Name: C. T. Gender: Male
Age: 43 Race: Caucasian
Marital Status: Married Education: 2 yr. College
Handedness: Left Ranchos Scale: IV

Presenting Problem(s): Agitation - swears, spits, hits, kicks; decreased frustration tolerance.

Target Behaviors: Verbal Outburst: any verbalization made in anger at a volume above normal speaking tone. Physical Outburst: actual physical contact with inanimate objects; attempt to make contact within arm's reach, or actual contact, with another person in anger. This includes any threatening gestures made in anger.

Interventions: Verbal Outburst:
Provide C. T. with 'stop' cue, raising hand gently, with palm of hand facing C. T;
All interaction with C. T. will cease until both of the following criteria are met: five seconds of silence and resumption of normal speaking volume;
Note success with procedure and offer verbal praise if he calms;
If calms, suggest how he could otherwise express himself.
Physical Outburst:
Offer one verbal 'stop' cue, prior to outburst (if possible);
praise successful calming;
Implement progressive calming protocol.

Data Type: Record number of outbursts as they occur, describing antecedents and reactions to consequences, as well as duration of the outbursts and restraints, if implemented. During periods of calm, remark on patient status every fifteen minutes.

Miscellaneous Information: PRN medication is available (Haldol 10 mg IM). If C. T. does not calm within one-half hour of being placed in cloth restraints, attending physician is to be notified and he/she will prescribe medication.

APPENDIX H

POST-DISCHARGE QUESTIONNAIRE

TREATMENT EFFICACY OF A NEUROBEHAVIORAL REHABILITATION
PROGRAM FOR DECREASING AGGRESSIVE BEHAVIORS EXHIBITED BY TWO
INDIVIDUALS WITH FRONTAL LOBE DAMAGE

Post-Discharge Questionnaire Statement of Purpose

Subject:

Date:

The purpose of this questionnaire is to describe the aggressive behavior(s) exhibited by (subject) following his/her completion of the neurobehavioral program. The data that is gathered through this questionnaire will be used in conjunction with the behavioral frequency data that has been collected while (subject) was administered inpatient services in the neurobehavior program. It is necessary to collect this information at the present time in order to assess the longer-term effects that (subject's) behavior modification plan may have had on his/her aggressive behaviors.

The ethical code of psychologists requires that the description of research subject's demographic information, performance on tests, etc. must be held in confidence. The information in this study will be presented in such a way so as to protect (subject's) right to privacy.

Post-Discharge Questionnaire

Subject:

Date:

Behavioral

- 1.) Is (subject) residing at home? If not, where is (subject) residing?
- 2.) How many verbal and physical outbursts occur daily? Weekly?
- 3.) Has there been a change in the characteristics of the physical and/or verbal outbursts exhibited by (subject) since being discharged from the neurobehavioral program?
- 4.) When these outbursts occur: How long is their duration? What do you and other family members do? Is there a particular time that they occur? Is there a particular antecedent prior to the outburst?
- 5.) Is (subject) attending outpatient rehabilitation services on a regular basis? If yes, what types of treatment is he/she receiving (e.g. PT, OT)? How many times per week and for how long per sessions? Do outbursts occur during such sessions? If they do, do they occur more frequently than at home?
- 6.) If seeing a mental health professional (e.g. rehabilitation counselor), has (subject) been placed on any type of behavior management plan targeting verbal and/or physical outbursts? On what other issues is (subject) and counselor/therapist working?

Medical

- 7.) Have any neurological examinations been administered since discharge? If so, has there been any significant structural and/or functional changes noted? What diagnoses and conclusions were given? Any other examinations or testing evaluations? If so, please describe their nature and conclusions.
- 8.) Is subject still being prescribed medication? If so, what is (are) the medication(s) prescribed, including schedule, dosage and purpose?

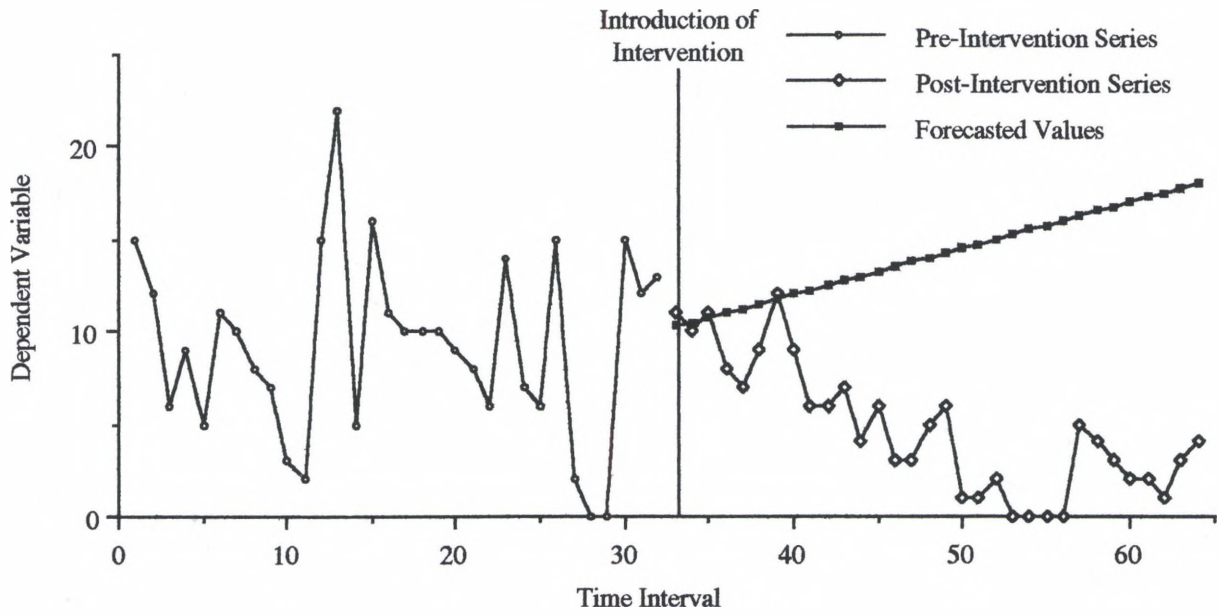
Social

- 9.) Any significant changes in social or work activities during the length of time from discharge to the present? Has (subject) returned to work (if working before incident)?
- 10.) How does (subject) occupy his/her spare time? Is (subject) following any scheduled daily routine?

Any other comments or information are welcome concerning the effects of the neurobehavior program on (subject's) aggressive behavior.

APPENDIX I

GRAPHICAL REPRESENTATION OF THE ARIMA MODEL
FOR DETERMINING INTERVENTION IMPACT



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