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Premature Infant Responses
to Taped Maternal Voice

by

Maryann Bozzette

A dissertation submitted in partial
fulfillment of the requirements for the degree of

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Date June 4, 1997

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Abstract

Premature Infant Responses to Taped Maternal Voice

by Maryann Bozzette

Chairperson of the Supervisory Committee
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Premature infants are at risk for many potential problems including deficits in social interaction and sensory perception skills. One of the major reasons for this is the relative social isolation of these infants housed in incubators and separated from parents. There is a need to identify social stimuli that may be provided for premature infants that will encourage normal development without adding additional stress. The purpose of this study was to describe the behavioral (facial, motor, activity, visceral, state, and attending) and physiologic (heart rate, respiratory rate, and oxygen saturation) responses of premature infants to taped maternal voice. Fourteen stable premature infants from 31 to 34 weeks gestation were monitored and videotaped four times each day for three consecutive days during the first week of life. Each infant served as his own control providing baseline, tape and post tape measures for each of the 12 study sessions. The data for each individual infant and all of the infants as a group were compared over these three study conditions.

The results of this study suggest that premature infants are capable of attending to intermittent exposure to taped maternal voice without undue stress. There were no significant differences in heart rate, or oxygen saturation throughout the study conditions. There was a trend toward significance in lower respiratory rates from the baseline to the tape segment. There was a significant increase in respiratory rate during the post tape segment when compared to the tape segment.

From the baseline to the tape segment, the infants showed significantly higher amounts of attending. Stability behaviors were significantly higher during the tape segment as well as attending behaviors when compared to the

post tape segment. From baseline to the post tape segment, the infants were more likely to be asleep, but continued to show more attending behaviors if awake. There were significantly less stability behaviors from baseline to post segment. The infants trended toward less activity during the taped segment and more wakefulness. The level of stress was minimal across all study conditions.

The findings of this study indicate that premature infants in early gestation are responsive to taped maternal voice. Although attending behaviors were not present in all of the sessions, significantly more attending behaviors occurred during the tape segments overall. Taped maternal voice appears to be a nonstressful stimulus for premature infants that may potentially facilitate social responsiveness.

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To my father, who has taught me
what courage is

CHAPTER I: Significance

Prematurity presents a multitude of potential developmental risks for an infant with virtually every system susceptible to modification or deficit. Poor nutritional status and growth, muscular and motor deficits, neurological impairment and poor sensory and integrative skills are hallmark areas of concern (Als, 1986; Als, Duffy, & McAnulty, 1988; McCormick, 1989; Rose, 1983; Siegel, 1994; Sigman, 1983). Underdeveloped physiologic systems at the time of birth require immediate medical intervention and these factors place the infant at risk for complications such as intraventricular hemorrhage and bronchopulmonary dysplasia. Due to the life threatening physiologic and pathophysiologic problems associated with a premature birth, areas of growth that receive the least attention early on are those involving the emotional and social development of the infant. Areas to be considered include the vast array of environmental stimulation that is experienced by premature infants that is neither comparable to normal infants or conducive to optimal development.

The environment of the neonatal intensive care unit (NICU) has been scrutinized for its continuous illumination, noise and multiple caregivers contributing aversive stimuli for premature infants (Als, 1982; Barnard & Blackburn, 1985; Field, 1990; Gorski, Huntington, & Lewkowicz, 1990; Gottfried, 1985). Although concerted efforts have been made to improve these conditions (Als, 1986; Becker, Grunwald, Moorman, & Stuhr, 1993; Lawhon & Melzar, 1988; Als et al., 1994; Fleisher et al., 1995), the NICU is a vastly different environment than the womb. In fetal life, the cardiorespiratory and regulatory systems are supported by maternal blood flow and placental functioning. Rhythmic stimuli are provided by maternal activity, hormonal cycles, as well as auditory, cutaneous, and kinesthetic input via the amniotic fluid and sac (Als, 1986; Blackburn, 1986). After birth and admission to the NICU, medical technology takes over fragile systems. The infant no longer receives the cyclic stimulation and diurnal rhythms of the intrauterine environment. Even more disconcerting is the potential danger for the premature infant's brain. The brain undergoes its most rapid period of development in the last 12 weeks of gestation. These crucial events are now occurring in the strange and overwhelming environment of the NICU (Parmalee & Sigman, 1983).

It is well documented that certain timed experiences are required for sequential development to occur. In other words, the developing nervous system expects stimulation will be provided at specific times and in specific patterns. If an abnormal pattern of stimulation is provided, an abnormal pattern of neurorganization will occur (Greenough, 1987).

Other pertinent aspects known about this period of gestation are that glucose utilization and development occurs early in the sensory motor cortex of the brain and proceeds subsequently to the frontal cortex during early infancy. Information incorporated by earlier structures may be utilized in the organization of the rest of the central nervous system (Levine, 1987).

Since the current NICU environment provides a variety of stimulation that is not organized, patterned or tailored to progressive experience, this orderly process is disrupted. If experience is necessary for the normal sequence of development, then provisions to ameliorate the abnormal and provide meaningful experiences are warranted.

The purpose of providing an intervention during this time is not to enhance or accelerate development, but to allow development to continue in an organized manner and prevent future problems. This is particularly salient given the current state of the art for neonatal care.

The technological advances have steadily improved survival rates for very low birth weight infants over the last decade. It is now possible to save premature infants as young as 23 weeks gestation. Although mortality rates have stabilized, morbidity continues to be major concern particularly with infants of decreasing gestation. These advances have also increased the amount of time infants are developing within the NICU environment (Ehrenhaft, Wagner, & Herdman, 1989; McCormick, 1989). Consequently, there is a dramatic increased risk for social, cognitive, perceptual and motor deficits (Bendersky & Lewis, 1994; Bowman & Yu, 1989).

These factors have created concern for the subsequent social and emotional health of these children beyond physiologic survival. The ability to successfully integrate into society and achieve a level of productive function are normal expectations of children. Infants must be able to extract and process information from their surroundings in order to learn and effectively interact with others.

Premature infants begin their lives in relative social isolation. When social contact is attempted, they typically display a low tolerance for expected interactive processes which is both disappointing and stressful for parents. For example, premature infants are difficult to engage, displaying frequent gaze aversion and less animated facial expressions. Coupled with a lengthy hospitalization, this pattern is a threat to parent infant attachment and early social interaction skills (Goldberg, 1978; Minde, 1992; Sostek, Quinn, & Davitt, 1979). Even when medically stable and finally at term gestation, premature infants are ill-equipped to enter the social environment of the outside world. Since the NICU currently provides a predominance of caregiving interventions, and fewer social opportunities, social stimulation is often neglected or inappropriately timed (Barnard & Blackburn, 1985).

Many questions concerning influences on social development in premature infants are currently unanswered. These include the manner by which infants in the early stages of neurobehavioral development learn to process signals that are sent from other humans and subsequently learn to reciprocate and establish social behavior. Another is the sequence of events that needs to occur for successful interactive relationships to evolve. A major question related to this research involves identification of potential interventions that can encourage or foster social development but at the same time are not too stressful or overwhelming for a premature infant to handle.

Infant stimulation for premature infants has been approached from all sensory modalities including multimodal stimulation (Field, 1986; Gorski, 1991; Harrison, 1985). This pattern has led to criticism and confusion about the usefulness and timing of these programs (Gorski, Huntington, & Lewkowicz, 1990). When considering an appropriate intervention, it was felt that the stimulus must have some particular meaning to the child, and be provided in a nondisruptive manner. Additionally, when several types of stimuli are presented concurrently, it is difficult to determine which stimulus is most effective. Therefore examining one type of stimulation seemed most appropriate for the current investigation.

Non-patterned stimuli are frequent in NICU and may be aversive to premature infants. Patterned stimuli, such as mother's voice, are perceptible to premature infants and may provide a regulatory effect and be instrumental in organizing early behavior. Maternal voice is a salient stimulus for infants and can potentially enhance attachment relationships, future interactive capabilities, and sensory integration skills. Long term benefits from a variety of modes of stimulation have been examined by several groups, but none have examined the immediate responses of premature infants or change over time in the pattern of responses. In addition, tape recorders are routinely used in the NICU to provide a variety of auditory stimulation without established parameters for use, or documentation of positive or negative responses. Therefore, research is needed to validate responses to auditory stimulation, and to determine if positive effects are present. There is also a need to establish that there are not negative effects on infants particularly with repeated exposure.

Purpose

The general framework for this study was focused on examining a single medium that served the purpose of providing relevant, patterned, and nonaversive stimulation in order to observe the immediate response of infants. Additionally there was a desire to explore the usefulness of the stimulus as an intervention to augment perceptual processing and improve premature infant responsiveness. An area of research for which there is currently little information is the positive experiences that premature infants may be provided during the period of time prior to reaching term. A potentially potent source for that experience is the premature infant's mother. The specific purpose of this research was to describe the effects of taped maternal voice on premature infants studied during the first week of life. The major issues at question were the safety of using taped maternal voice as a stimulus as well as examining potential benefits for premature infants. The pattern of responses for each infant was determined, as well as the effect of exposure over time to their mother's voice.

Research aims:

The specific aims of this study were to describe:

1. the immediate effects of a novel stimulus, taped maternal voice, on behavioral (activity, attention, state, motor, facial expression and visceral responses) and physiologic (heart rate, respiration and oxygen saturation) responses of premature infants;
2. the behavioral and physiologic responses of premature infants to repeated exposure to taped maternal voice;
3. the effect of infant state on the responses of premature infants to taped maternal voice.

CHAPTER II: Review of Literature

Introduction

There are several aspects of human development that are related to this research. These include, the early evolution of emotional affect, elements of social interactions, characteristics of the attachment relationship, arousal and attention, sensory processing, auditory function and cognitive function. Premature infants are defined as infants who are born at or prior to 37 weeks gestation. The majority of information that is currently known concerning the functional abilities of premature infants has been derived from the period of time after these children reach term gestation. This review focuses on related aspects of normal social development and issues specific to premature birth.

Social Development

From the time of birth, a human infant must be cared for by other humans and remains dependent on others longer than infants from any other species. The study of parent-infant interaction evolved from this understanding that humans are social beings and dimensions of the parent-infant relationship influences all developmental processes (Beckwith, 1979). The family in turn is embedded in a broad variety of social systems (Bronfenbrenner, 1977). The larger environment acts as both a stressor and a support for the parent-child relationship. Social development normally proceeds with proximity to nurturing parents from the moment of birth. When an infant is born prematurely, development is threatened by separation, and the loss of regular, patterned stimulation usually provided by parent-infant interactions.

Research over the last few decades has revealed that the parent- child relationship is more complex than previously determined (Collins & Gunner, 1990). Successful interactions reflect parental abilities and actions as well as those of the infant. Both are germane formative factors in early social development. Patterns of interaction distinguish infants at risk for developmental failure from those developing normally (Sigman & Parmalee, 1979). Emotional affect, aspects of social interaction such as the content and timing of behavior, and attachment are three major factors influencing the developing relationship within the social development paradigm (Campos, Caplovitz, Lamb, H., & Stenberg, 1983; Hinde, 1991; Sroufe, 1979).

Interaction and Emotional Affect

The emergence of emotions in infancy are closely intertwined with early social interactions. Emotional affect molds the qualitative features involved in interactive exchanges. The parent's ability to perceive and interpret a child's signals and intentions and respond quickly and appropriately has been called *sensitivity* (Brazelton, Koslowski, & Main, 1974). Contingencies between infant actions and the environment foster motivation, decrease crying, advance ability to process information, and promote cognitive competence (Campos, et al., 1983). Through interactions with responsive adults, infants develop competence as effective agents of their own experiences. They also develop distinctive expectations of adults which influence behavior and the quality of interactions (Lewis & Goldberg, 1969). These interactions in turn facilitate a system of coherence and self-regulation (Lamb, 1982; Lewis, 1987).

Closely related to sensitivity is the concept of *synchrony* which refers to the precise timing of interactions to provide mutual regulation of the participants (Brazelton, et al., 1974). *Reciprocity* refers to the mutual contribution of the parent and infant to the interaction and their responsivity to one another (Bornstein, 1989). Emotions are dynamic regulators of interpersonal processes (Emde, 1980). They are considered to play a crucial role in appraising the meaning of events and in the integration of behavior. The main route of communication for preverbal infants is through emotions which are outwardly displayed in their behavior.

Parental sensitivity and *attunement*, or ability to display behavior that indicates the quality of feeling a shared affective state are closely related processes that enhance the infant's ability to accurately encode information and learn to produce behavior that contributes to their understanding of the world (Stern, 1988). *Emotional availability* is a state of readiness that communicates to the infant that the parent is aware of the infant's presence, is monitoring his or her behavior, and is available to respond appropriately (Emde, 1980). Cues, or readable behavior are an essential component of successful interactions (Emde, 1980).

Following a premature birth, interaction difficulties are frequently observed and thought to be a potential threat to successful development (Beckwith, 1984; Bendersky & Lewis, 1994; Cohen, 1995). Studies on interaction are conflicting in their reports, with some showing minimal differences between preterm and full term infants by the end of the first year

(Landry, Chapieski, Richardson, Palmer, & Hall, 1990). Mothers are reported to be both overstimulating with persistent intrusive behavior even when the infant is not responding (Field, 1979; Malatesta, et al., 1986, Magyary), and understimulating with less time spent with infants, less talking, less cuddling and less positive affect (Alfasi, Schwartz, Brake, Fifer, Fleischman, & Hofer, 1992; Goldberg, 1978; Holditch Davis & Thoman, 1988;). When infants are followed for longer periods of time, disturbing patterns appear to reemerge or continue (Barnard, et al., 1984; Magyary, et al., 1992).

Early parent-infant interaction is a dynamic feedback system that prototypes all future social relationships and influences the progressive course of affective responses (Lewis, 1987). Interaction can be influenced by both infant and maternal characteristics. When compared to term infants, premature infants are less animated and have demonstrated a much lower level of alertness and attention during interactions (Coll, 1990; Malatesta, Grigoryev, Lamb, Albin, & Culver, 1986; Stiefel, Plunkett, & Meisels, 1987).

Maternal characteristics may also enhance or impede infant social development. Those already mentioned such as sensitivity and attunement are most likely to enhance this process. High anxiety, perceived fragile state of the infant, and personality traits such as rigid attitude, may alter a mother's ability to facilitate interactions with their infants (Butcher, et al., 1993; Gennaro, 1985; Macey, Harmon, & Easterbrooks, 1987; Patterson & Barnard, 1990). It has been repeatedly noted in follow-up studies that premature infants are less rewarding to parents and sometimes the amount of parental time spent with the infant decreases as the child gets older (Barnard, Bee, & Hammond, 1984; Crawford, 1982). Since these children need more structure and support, subsequent development may suffer if the parents become less involved as time goes on. In more recent longitudinal studies prematurely born children seem to have more difficulty as they get older. Even when premature children initially show good progress, decline of intellectual function has been found between the first and third birthdays (Engelke, Engelke, Helm, & Holbert, 1995). The authors attribute this finding to the social environment rather than perinatal events.

Mothers of premature infants have been found to be less imitative and responsive early on, and in subsequent months have shown overactive, intrusive behavior particularly if their infants have had significant medical problems (Beckwith, 1992; Field, 1987; Field, 1979; Magyary, 1984). Mothers report less joy and more work involved in engaging their infants (Crnic, Ragozin, Greenberg, Robinson, & Basham, 1983; Field, 1979; Goldberg, Perrotta, & Minde, 1986). In addition mothers of premature infants use less body contact, spend less time in face to face interactions and smile less at their infants (Beckwith, 1984; Gottwald & Thurman, 1990; Macey, et al., 1987; Magyary, 1983).

Although most studies terminated after the infant's first year of life, follow-up of premature infant dyads beyond 2 years of age continue to reveal somewhat disturbing interactions as well as delays in language and behavior problems (Barnard, et al., 1984; Field, 1987; Magyary, Brandt, Hammond, & Barnard, 1992; Plunkett, Meisels, Stiefel, Pasic, & Roloff, 1986). Prematurity seems to have a significant effect on mother's and infant's ability to contingently respond and organize their behavior around one another (Magyary, et al., 1992). There has also been some suggestion of maternal burnout in that when infants finally become more responsive, the mother reduces her involvement (Beckwith, 1984; Malatesta, Grigoryev, Lamb, Albin, & Culver, 1986).

The heterogeneous nature of prematurity has resulted in a diversity of outcomes. Some infants with relatively mild perinatal distress later have more deviant developmental patterns (Cohen, 1995). The state of the child's health and parenting seem to be two outstanding factors in determining ultimate development (Bendersky & Lewis, 1994; Bradley, Caldwell, Rock, Casey, & Nelson, 1987). The rearing environment is a potential source for either preventing or augmenting deficits. Aspects of the child's environment have repeatedly correlated highly with developmental outcome (Bendersky & Lewis, 1994) particularly the organization and stimulation provided by parents (Bradley, Caldwell, Rock, Casey, & Nelson, 1987) and degree of infant responsiveness (Butcher, Kalverboer, Minderaa, van Doormaal, & ten Wolde, 1993). The importance of improving the social environment for children born at risk cannot be overemphasized (Cohen, 1995).

Attachment

Attachment as described by Bowlby (1982) stresses the importance of the developing intimate relationship with a primary caregiver during the early months of life. The establishment of personal identity, the regulation of emotions, and the formation of internal representations that become the basis for future relationship patterns are established in this earliest social relationship (Hinde, 1991). Successful interactions are considered to be the cornerstone of secure attachment patterns and a reflection of overall developmental status (Hartup, 1985). The content, patterning and quality of interaction are essential elements of interpersonal relationships. Secure attachment evolves from goal-directed situational control and leads to greater social competency.

It is known that infants thrive in an environment which provides social contact and exposure to a variety of sensory experiences. For the premature infant, integration of these modalities must be carefully facilitated. The unexpected and stressful nature of a preterm birth places both the parents and infant in an uncertain and unfamiliar world of multiple surrogate caregivers and technological devices (English, Parry, & Donovan, 1987; Gennaro, 1985; Miller & Holditch-Davis, 1992; Seifert, Thomson, Densel, & Hunt, 1983). The unnatural separation puts the parents in the role of bystander, interrupting not only the expected life pattern, but the initial acquaintance process with their infant. These factors along with the premature infant's instability and early phase of development places the family at high risk for interactive failure.

Early separation denies the opportunity for mutually rewarding affective reciprocity and can have devastating consequences. Long-term illness in a premature infant has shown a more powerful effect on the mother's degree of interaction than have otherwise important psychological variables in the mother's background such as previous loss and attribution style (Minde, Whitelaw, & Brown, 1983). In addition, follow-up research on premature infants shows the degree of illness and medical complications, most specifically respiratory illness, are powerful contributors to disorganization of behavior in these children (Field, Dempsey, & Schuman, 1983; Landry, Chapieski, Richardson, Palmer, & Hall, 1990; Macey, Harmon, &

Easterbrooks, 1987; Minde, et al., 1983). Improving interactive exchanges, particularly re-establishment of rhythmicity within the maternal-infant dyad encourages the organization of behavior and reinforcement of positive experiences (Lester, Hoffman, & Brazelton, 1985). Efforts to increase responsiveness of preterm infants is expected to strengthen this process (Coll, 1990; English, et al., 1987; Field, 1981). In a recent study by Butcher et al., (1993) infant responsivity was the most highly correlated variable to secure attachment relationships.

Social Competence

A theoretical framework of social competence is proposed as a basis for developing strategies to enhance the socioemotional development of premature infants. Social competence for premature infants involves three major conceptual areas: adaptive capacity for the extrauterine environment, neurobehavioral organization, and social interactive abilities. Social development integrates the innate abilities of the child with the world and other human beings (Campos, et al., 1983). The brain is activated by sensory input and experience is the basis for and stimulus of growth (Hack, Mostow, & Miranda, 1976). In order for competence to develop, an infant must learn to maintain an attentive state and be able to orient to visual or verbal cues (Cohen, Parmalee, Beckwith, & Sigman, 1992). Competence evolves from the ability to observe and engage in a variety of experiences. It is qualitatively more than perception and cognitive function. In early infancy, competency is the regulation of physiology and behavior and establishment of a smooth functional relationship with caregivers (Sroufe, 1979).

Adaptive capacity

To say that an organism is adapted means it is organized in relation to some aspect of its environment. Historically, adaptation is a process which leads to fit or functional relationships, including adjustments occurring during a lifetime that preserve a specific function or purpose (Alberts, 1987). The ecological context or "niche" is extremely important to adaptation. Mutual regulation and integration is produced by continuous dynamic interaction of the infant within his environment (Sameroff, 1986). These mutual influences probably determine the course of development and may ultimately be more influential than early biomedical status.

Development can be characterized by sequences or stages of adaptive organization that are dependent on coordinated and integrated readjustments over time. Together this integrated, multi-leveled synergy of elements comprises an adapted organism (Alberts, 1987). Susceptibility is the absence or impairment of adaptive responses (Gabarino, 1992).

Adaptive capacity reflects the ability of a system to respond to and restore stability in the face of external or internal challenges (Mitchell, 1986). The premature infant's adaptive capacity can be described as the ability to adjust to the changing environment and achieve and maintain equilibrium while continuing the process of maturation. Quantifiable measures of adaptive capacity are self-regulation or the behaviors which promote and maintain homeostasis, and avoidance behaviors which are the active resistance to aversive stimuli. Adaptive capacity is dependent upon central nervous system regulation and the strategies used by premature infants are less developed due to their gestational age. The transition to the extrauterine environment is abrupt and untimely for the premature infant and differences in developmental outcome are a composite reflection of medical status, environmental demands and infant integrity. Adaptive capacity may be the reason for such wide variability in developmental findings as well as the source of successful intervention.

Neurobehavioral organization

Neurobehavioral organization is the establishment of integrative function between the infant's physiologic, sensory and behavioral systems. Neurobehavioral organization evolves from the interplay of both neurologic and behavioral dimensions of human infants while in dynamic transaction with the environment. This process results in the progressive differentiation and modulation of function (Als, Lester, & Brazelton, 1979).

The organized infant is able to handle stimuli while maintaining autonomic nervous system stability (Als, et al., 1988; Gorski, Davison, & Brazelton, 1979; Lawhon & Melzar, 1988). Another indication of neurobehavioral organization is the emergence of distinct states or levels of consciousness (Als, et al., 1988; Gorski, et al., 1979). The traditional categories of infant state include regular or quiet sleep, irregular or active sleep, drowsiness, alert inactivity or quiet alertness, waking activity or active awake, and crying. Mature infants have clear, robust states with smooth transition from state to state reflecting ability to modulate and attend to the environment (Parmelee, 1974).

Premature infants show an irregular pattern of state regulation with more diffuse states of consciousness. Most sleep is active with little discernible quiet sleep or robust crying (Parmalee & Sigman, 1983). They are less able to orient to stimuli and spend more time in non-alert waking and sleep-to-wake transition states than full-term infants (Holditch Davis & Thoman, 1987). Distinguishable sleep states by EEG patterns emerge by about 31 weeks. However, levels of alertness are changeable and last for shorter periods in premature infants until about 35 weeks when more mature forms of state regulation develop (Curzi-Dascalova, Peirano, & Morel-Kahn, 1988).

Initially, premature infants present with varying degrees of medical instability and complicating factors in their early recovery. If not well regulated, the caregiving environment can add stress to an already compromised infant (Peters, 1992). Disruption of sleep in premature infants has been reported as often as 14-20 minutes each hour (Duxbury, Henly, Broz, Armstrong, & Wachdorf, 1984). Recovery, growth, and development are threatened by stress, and frequent handling can sometimes upset the balance for these infants with observable cost. Poor modulation, irritability, and physiologic instability may be accounted for by environmental conditions as much as by physiologic immaturity. This knowledge has led to the evolution of naturalistic caregiving stimulation designed to attenuate distress behavior during invasive procedures (Field, 1990) as well as protect the infant from multiple sources of stimuli that are too overwhelming to process (Als, 1982; Als, et al., 1988). Brain electrical mapping or BEAM has suggested that even minor noxious events may have a cumulative effect on central nervous system organization and disrupt normal development (Duffy & Als, 1989).

Neurobehavioral organization is viewed as a balance of regulatory subsystems that allows an infant to maintain levels of relaxation and attentiveness. Organization promotes adaptation, while disorganization may be a reflection of a either transitions between patterns or repatterning; immaturity; deviation; or pathology (Als, 1986). The newborn's capacity for self regulation is the beginning level of function and development. The newborn infant must not only regulate a single system but must coordinate the activities of a large number of physiologic and behavioral systems within the context of a constantly changing, often novel environment.

The premature infant is thrust into the world in the early stages of neurodevelopment and intrauterine experiences that normally provide an organizing function has been interrupted. Als (1986) has proposed a model for neurobehavioral organization of premature infants called the Synactive Theory of Development consisting of five interrelated systems: 1) autonomic, 2) motor, 3) state, 4) affectional/interactive, and 5) self-regulatory. Each of there subsystems are interdependent and hierarchical and mature sequentially.

Autonomic subsystem. This system is represented by the stabilization of physiologic functions such as heart rate, respiration, color, digestive and eliminative function. A disorganized condition of this subsystem would be characterized by the presence of such events as bradycardia, apnea, color changes such as mottling, and visceral reactions such as gagging and regurgitation.

Motor subsystem. Motor activity includes tone, posture and patterns of movement. Organized motor function wound be seen in smooth coordinated movement and strong muscle tone. Flaccid posture, or increased jerky movements or twitching would represent disorganization.

State subsystem. The ability to maintain state or make smooth transitions between states is the goal of this subsystem. Premature infants as already stated have more diffuse states and greater liability of states.

Interactive-attention subsystem. This subsystem is demonstrated by the infants ability to orient to and focus on sensory stimuli. The organized infant is receptive to emotional and sensory input. Gaze aversion or hyper alert conditions where the infant is unable to disengage from a stimulus, would represent disorganization of this subsystem.

Self-regulatory system. The regulatory system represents the ability to establish and maintain a state of balance and relaxation in the presence of varying demands. A smooth integration of subsystems is reflected in self regulation. Premature infants frequently cannot self regulate without facilitation and are very sensitive to the timing and amount of stimulation. In this synactive model of development, organization of one subsystem permits the beginning differentiation of another subsystem.

Neurobehavioral organization can be thought of as a systematic progression during which the central nervous system is differentiated and parallels the emergence of infant states. A premature infants behavioral repertoire has been suggested as the best assessment of central nervous system function. It provides a measurable estimate of the infant's ability to organize himself and to either attend to or shut out stimulation (Als, et al., 1988).

Social interactive abilities

The dimensions of parent infant interaction have been previously described. Research has shown differences in patterns of interactions of premature mother-infant dyads with vast majority of research focused on the behavior of the mother. Infants who were born prematurely are reported to be less attentive, less alert and more fussy than full term infants and do not give easily readable cues (Barnard, Bee, & Hammond, 1984; Divitto & Goldberg, 1979; English, et al., 1987; Field, 1987; Field, 1979; Goldberg, 1978; Macey, et al., 1987; Stiefel, Plunkett, & Meisels, 1987). Less positive affect has been reported in these infants showing less visual attentiveness and mothers failing to match emotional experiences consistently (Beckwith, 1984; Divitto & Goldberg, 1979; Minde, et al., 1983). Continuity and consistency across time is necessary and it is the cumulative effect that fosters competency (Beckwith & Cohen, 1989). Vocalization seems to have the greatest impact in keeping a preterm infant engaged as shown by longer periods of eye opening and looking (Eckerman & Oehler, 1992).

The transactional nature of interaction emphasizes the equal importance of infant contribution to the interactive process. Interventions are needed to emphasize that the infant is not a passive participant. The infant's role in interactions includes behaviors and characteristics such as temperament and attentiveness, particularly the effect infant factors may have on parent behavior (Osofsky & Connors, 1979). Premature infant characteristics include difficulty maintaining prolonged states of alertness; increased motor activity with less inhibitory processes causing increased reactivity; and weak musculature with poor balance of extensor and flexors relating to a flatter affect. A premature infant becomes easily exhausted and withdraws displaying higher thresholds for stimulation and lower intake levels for stimulation. (Als, Duffy, & McAnulty, 1988)

When only middle class families or low risk infants are studied, prematurity seems to have less of an effect on parent-infant interaction as the infants get older. Parent education, enriched environments and financial stability seems to be able to mitigate some of the early deprivation for premature infants. However, the majority of premature infants are born younger, sicker, and to poorer families (McCormick, 1992). Children from low socioeconomic groups have a higher incidence of interactive difficulties probably due to limited resources and support for these families (Stiefel, et al., 1987). Any maternal characteristic such as low self esteem or depression impairs the quality of interaction and decreases success. In addition, a higher number of premature children demonstrate an insecure attachment pattern and are over represented in cases of child abuse and neglect (Gaensbauer & Harmon, 1982).

Differences in findings across studies may be attributed to a variety of methodological procedures and sample characteristics. Early studies were performed in different situational contexts, mostly in a laboratory, and relied sometimes on a brief sampling of discrete behaviors. Studies also varied on the use of corrected age and frequently used a single observation. The methods used may have been either event or time-based coding, and both microscopic or macroscopic approaches were used for analysis. The type of interaction observed also varied. Observations may have been during a play session, a caregiving episode or a feeding session. In addition, there is a wide variation in chronological ages when infants were studied as well as health risk levels. The earliest studies rarely observed infants beyond 4 months of age.

More recent studies have used more than one measure of interaction and are observing infants in multiple time points during the first few years of life. Infants are more often matched for medical risk and gestational age. Even with better matched samples and methods, persistent differences remain in the way that premature mother infant dyads interact (Beckwith, 1992; Butcher, et al., 1993; Crnic, Ragozin, Greenberg, Robinson, & Basham, 1983; Landry, et al., 1990). Mothers need to work harder and have less satisfying interactions (Crnic, et al., 1983; Landry, et al., 1990; Malatesta, Grigoryev, Lamb, Albin, & C., 1986; Vohr, 1991). Most often, this can be attributed to the behavior and deficits in the infant (Crnic, et al., 1983; McGehee & Eckerman, 1983; Vohr, 1991).

Among the other sobering findings, at a time when children begin to relate to peers, infants who were premature at birth become more easily distressed and less able to adapt to new or challenging situations (Plunkett & Meisels, 1989). Behaviors reported by parents include impulsivity, difficulty attending to tasks, listening and following directions, and poor concentration (Klein, et al., 1989). Prematurely born children followed into early adulthood are showing more social differences as they get older (Siegel, 1994). These findings are prompting research methods beyond early global measures such as IQ and gross developmental tests (Alward, Pfeiffer, Wright, & Verhulst, 1989).

Thus, there is an intimate relationship between neurobehavioral organization and successful interaction ability. The interactive exchanges are in turn a reflection of the evolving attachment relationship. Behavior underlies interaction and provides a temporal structure for the organization of cognitive and affective experiences. An infant must be able to display some stability and organization of behavior in order to initiate, respond, or continue social interaction (Brazelton & Yogman, 1986). Emergence of neurobehavioral organization delineates not only the quality of the infant's response but also the duration of the response, the difficulty with which it is elicited and effort and cost involved in achieving and maintaining responsivity (Brazelton, 1973).

Cognitive function

In addition to socioemotional risks, follow-up studies of children who were premature at the time of birth have revealed significant deficits in cognitive and language development with lower reported developmental/IQ quotients and poorer school performance (Hack, Breslau, Aram, Weissman, Klein, & Borawski-Clark, 1992; Klein, Hack, & Breslau, 1989; McCormick, 1989; Rose, 1981; Siegel, 1983; Sigman & Parmalee, 1979; Vohr, Garcia-Coll, & Oh, 1989). Differences are also reported in visual and spatial functioning, fine motor coordination and working memory (Hack, et al., 1992; Klein, et al., 1989; Rose, 1981; Sigman & Parmalee, 1979). By school age, even children without major neurological insults are beginning to show signs of learning and cognitive delays (Hille, Den Ouden, Baure, van den Oudenrijn, Brand, & Verloove-Vanhoric, 1994). Sensory and perceptual deficits appear to be the most prevalent finding in these older children (Sostek, 1992). Limitations in attentional and behavioral problems have also been noted (Siegel, 1983; Siegel, 1994; Sigman, 1983; Sostek, 1992). A general deficit in cross modal transfer in infants born prematurely has been identified due to either a slow rate of information processing or poor sensory integration (Rose, Gottfried, &

Bridger, 1978). A major implication of these studies, is a challenge to the long held assumption that only children who had early neurological complications were at developmental risk.

Two recent evaluations of early neurobehavioral organization have demonstrated a strong relationship with later cognitive abilities. Rose et al, used the Einstein Neonatal Neurobehavioral Assessment Scale (ENNAS) measures on neonatal visual and auditory orientation to assess 144 premature infants at term. The infants were then tested with the Bayley Scales at one year, the MDI at two years, the Stanford Binet Intelligence Scale at three years, and the Wechsler Intelligence Scale at age six. Significant correlations between the neonatal assessments and IQ were found. In another study reported by Roth et al., (1994), The Griffiths Developmental Scales were administered at 12 to 18 months of age. At age four the children were tested with the McCarthy Scales of Children's Abilities. The Wechsler Intelligence Scale for Children, Revised was used with other screening tools when the children were 8 years. old. The results of this study demonstrated that the one year neurodevelopmental status was a significant predictor of outcome measures at eight yeas of age .

In summary, early social competence evolves from contingent and reciprocal transactions with the environment and other human beings. For premature infants, adaptation to the extrauterine environment as well as emerging neurobehavioral organization are mediating variables in this process. Concurrently, the growth of social skills is probably intricately tied with development of basic sensory discriminations. Human social and emotional characteristics are closely dependent on a number of perceptual and cognitive skills (Yarrow, 1979).

Perception and Attention

Perception is a complex process involving innate capabilities, past experiences, behavioral state, and the nature of information being processed (Haith, 1986). It is clear that contingent stimulation structures perception and fundamental regulatory systems which underlie adaptive behavior. With premature infants, exceeding the ability to maintain integrity of their developing systems is the basis of concern for their ultimate development and future abilities. In extremely premature infants it does not seem reasonable to expect much more than physiologic stability. As these infants continue to mature in the hospital environment however, it is necessary to determine appropriate stimulation to prevent alteration in their course of development. In addition, approaches need to be investigated for providing the necessary early experience for these infants to learn. Even immature organisms demonstrate an ability to learn (Alberts, 1987). A balance must be identified that will match the infant's interest and need for stimulation to his tolerance and ability to process information; the boundaries of which are still essentially unknown.

There is some evidence from animal studies that CNS synaptic connections, formation and selection occur on the basis of experience during early sensory development (Greenough, 1987). Newborn infants use every sensory modality to process environmental information and are capable of differential responsivity to stimuli from the time of birth (Lipsitt, 1990). Infants are capable of habituation, imitation and intentional behavior (Papousek & Papousek, 1986).

A dynamic model is emerging of intrinsic and extrinsic factors involved with early learning. It is believed that the initial environment provides the conditions for behaviors that will be learned and subsequently guide the child's reactions to similar conditions in the future (Sameroff, 1986). Newborns gain information by attending to relevant features of their environment and are dependent on variations in arousal produced by internal and external sources of stimulation (Olson & Sherman, 1983). Attention and arousal are interdependent homeostatic systems producing optimal CNS activation and organization (Karmel, Gardner, & Magnano, 1991).

In most species, the mother is the regulator of stimulation and physiologic rhythms. Studies on rat pups have delineated aspects of maternal behavior that modulate arousal (Hofer, 1987). Viewing mother as a regulator underscores a major difference for premature infants who do not experience extended contact with their mothers early in life. Failure of synchronous interaction or prolonged deprivation in animal models is manifested in affective disturbances ranging from decreased activity level to autonomic and biochemical imbalances (Hofer, 1987). Rhythmic cycles of attention and nonattention in arousal, parallel periods of engagement and disengagement that are part of social interaction (Lester, et al., 1985).

In nonhuman primates, disruption of mother-infants interaction is a potent variable that causes increased hypothalamic-pituitary-adrenal activity and results in changes in both neurochemical activity and behavior (Levine, 1987). In studies on both monkeys and rats, decreased immune responses as well as hypothalamic-regulated functions such as body temperature, sleep, metabolic rate and many autonomic processes have been altered with premature maternal separation (Lubach, Coe, & Ershler, 1995). Adrenocortical activity may be associated with both behavioral distress and behavioral withdrawal (Gunner, Larson, Hertsagard, Harris, & Brodersen, 1992). A relationship has been found between maternal sensitivity and changes in emotional behavior of infants and adrenocortical activation. Spangler et al. (1994), has demonstrated that insensitive mothers have produced higher levels of salivary cortisol in infants when observed during play at several time periods throughout the first year.

In a review reported by Levine (1987), investigators have demonstrated the presence of familiar visual or auditory access to the maternal figure can ameliorate the adverse biologic or behavioral responses when these stimuli are not available to the isolated primate infants. Data from these studies suggest that highly salient social stimuli, even in the absence of contact, results in increased ability for appropriate coping responses in order to reduce levels of arousal. Maternal voice is a stimulus may provide this type of regulation for premature infants.

With term gestation, infant skills for habituation and preferences for novelty as well as temporal organization are salient aspects of the attention-arousal system (Zeskind & Marshall, 1991). Newborns not only perceive but modify their behavior as a function of repeated interactions with the environment. Newborns are able to discriminate, orient, habituate, and dishabituate to familiarized stimuli and recover attention to novel stimuli (Haith, 1990; Lipsitt, 1990). Learning occurs through both classical conditioning and instrumental associations among a wide range of stimuli and sensory modalities. Papousek and Papousek (1986) described the following essential elements for the capacity of the infant to learn: an alert state, a patterned structure of stimuli, repetition of trials, gradual ordering of tasks in terms of complexity, use of adequate reward, and sensitivity to feedback signals.

Limited data on premature infants demonstrates differences in rate and intensity of responsivity that seem to be related to CNS organization (Rose, 1983). Results however are highly variable and it is currently unknown how much might be attributed to abnormal stimulation, absence of stimulation, or medical complications. It is also unclear if weak or inconsistent responses represent lack of reserve and or poor coping mechanisms. It is possible that similar capabilities as seen in the term newborn are present in early gestation infants but have not been identifiable to date.

Attention is believed to include both overall levels of arousal as well as selection and effort (Berg & Berg, 1979). The most general indicator of attentiveness is infant state, or overall level of alertness. Differences in responses to stimuli are reported when infants are tested in different states categories (Karmel, et al., 1991). In general, attention and learning requires a quiet, alert state.

Autonomic reactivity is also a sensitive index to environmental events and is often a variable used to determine attention (Berg & Berg, 1979). The most general measure currently being used is a change in heart rate. Heart rate can either accelerate or decelerate from baseline and significance is attributed to these events. In classic work by Graham and Clifton (1966) it was proposed that heart rate deceleration in term infants is a component of orienting or attention whereas heart rate acceleration is a component of the defensive or fear reaction. It has been difficult to demonstrate cardiac orienting response in newborns which seems to be condition dependent. For example, results are affected by the nature of the stimulus, the modality of the stimulus or the current state of the infant. Lester et al., (1990) found that premature infants have less change in deceleration, variance and power spectrum in the periodic variation in heart rate when attentional responses are examined with the Brazelton Neonatal Behavioral Assessment Scale. Possible explanations for these findings are a lower threshold for stimulation and less parasympathetic control.

Other autonomic responses to novel intense or particularly significant environmental events include sweat gland activity, pupil dilation, and EEG changes (Berg & Berg, 1979). Sucking suppression has also been used as a psychophysiological measure of arousal due to the fact that there are limitations in human processing for simultaneous activities. Young infants tend to inhibit their sucking when presented with novel visual or auditory stimuli (Olson & Sherman, 1983). Additional measures of attention in older infants have been visual preference models and eye fixation. Habituation has been the typical mode of investigating imitation and memory study in infants (Zelaro, Salomon Weiss, & Tarquino, 1991). By far the most common variables have been infant state, heart rate, and sucking suppression.

The premature infant, depending on gestational age at the time of testing, is often limited in ability to demonstrate many of these responses. Most current information on premature infants have indicated a delay in response to stimuli, a less intense response, slower habituation, greater difficulty abstracting relational properties of events, less preference for novel stimuli, and shorter periods of attentiveness. (Becker, Lederman, & Lederman, 1989; Field, 1979; Gardner & Karmel, 1883; Lawson, et al., 1984; Rose, 1983).

Energy and attention for learning is modulated by self regulation (Dawson, Panagiotides, Klinger, & Hill, 1993). Selective attending, and the perception of temporal contingent sequences involving an infant's own actions and external stimuli, provides the basis for early integrative processes (Aslin, Pisoni, & Jusczyk, 1983b). An interruption in the pattern of input to sensory organs, as well as exposure of immature systems during development to aversive stimuli, creates the potential for deficits in nuerobehavioral organization and may limit self regulation.

Issues of Infant Stimulation

It is now believed that newborns can create a mental representation for repeated stimuli. Prolonged exposure allows the infant to make a memory trace of the stimuli and actively compare new information with the mental representation (Zelaro, et al., 1991). There currently is an absence of information regarding the gestational age at which this may occur. Premature infants, due to high levels of undifferentiated neuronal activity, or possible CNS insult, seem to have a reduced dynamic homeostatic range for input (Parmalee & Sigman, 1983). Although responses are documented, they are more difficult to obtain, less strong, and wax and wan (Karmel, et al., 1991). Premature infants who were 30 weeks gestation at birth and tested at 37 weeks, have shown a long latency to examine stimuli and high reactivity to them (Krafchuk, Tronick, & Clifton, 1983).

There is currently discrepant views of infant stimulation in the NICU. Some view the environment as sensory deprived and devoid of necessary experiences. Other feel that premature infants are bombarded with stimuli, most of them aversive in nature. It has been acknowledged that perhaps the major problem lies in a dearth of *appropriate* stimuli (Cornell & Gottfried, 1976; Gottfried, 1985).

The beneficial effects of stimulation results from either rousing or quieting infants (Barnard & Blackburn, 1985). Activities that arouse or alert may bring the infant to more focused attention to the environment. Activities that soothe, allow for processing of environmental input. Most stimulation programs have reported some benefit for premature infants (Barnard, Snyder, & Spietz, 1991; Field, 1986; Korner, 1990; Resnick, Armstrong, & Carter, 1988; Schaefer, Hatcher, & Barglow, 1980). There are also some data to support the notion that neonatal sensorimotor functioning is accelerated by early extrauterine input. Some premature infants have demonstrated developmental milestones earlier than what was expected without stimulation (Sostek, et al., 1979). This suggests that attention and orienting abilities may also be fostered and attenuated.

The goal of sensory stimulation is to reestablish developmental trajectories, maintain and facilitate them. The scarcity of data concerning sensory processing in premature infants has precluded the design of scientifically based intervention programs and the prediction of effects. Most studies have only observed these infants once they have reached full gestation. As a result, little is known concerning the abilities of prematurely born infants prior to term.

The capability for abstracting meaningful information from the world is paramount to future functional status. Ways to provide the necessary input in a nonstressful mode in a controlled and predictable manner are desperately needed. This is particularly important given the amount of time that some premature infants are currently in the extrauterine environment prior to the optimal time of birth.

Some of the main factors to consider when determining the appropriate intervention are the experiences that normally occur at mid to late gestation during fetal development. Fetuses during the growth process are in a dark environment and subsequently not visually stimulated. They are contained in fluid, and receive vestibular experience with movement. They have tactile stimulation due to contact with the amniotic sac, but are not touched by human hands. They frequently hear intermittent sounds from their mother's body and voice (De Casper & Spence, 1991). Based on these known fetal experiences, and the desire to enhance neurobehavioral organization and prepare premature infants for further sensory integration, a prominent source for potential investigation is sound as a stimulus. Sound has been shown to increase the attention of premature infants when observed for reactions to moving objects (Lawson, Ruff, McCarton-Daum, Kertzberg, & Vaughan, 1984). There is a strong association with auditory discrimination abilities in infancy and later cognitive test scores. Caron & Caron (1988) have found that young infants seem to rely more on voice than face in making discriminations of emotional expressions. This phenomenon was replicated by Walker-Andres and Lennon (1993).

Auditory Development

In the term newborn infant, the physical structures of the outer and inner ear are well established at birth. Development of auditory pathways proceeds from peripheral to central. Auditory nerve and lower brainstem pathways of the auditory system are reported to be myelinated. As compared to the adult, the inferior colliculus and medial geniculate are partially myelinated and the auditory cortex is immature. Receptor cells are fairly well differentiated except at the basal area of the cochlea (Aslin, et al., 1983b; Parmelee, 1981; Rubel, 1985). The newborn cochlea requires high intensity stimuli and demonstrates long latencies and refractory responses to repeated stimuli indicating limitations in neuronal activity (Aslin, et al., 1983b). The auditory system consists of a series of components that transmit airborne sound pressure waves into neurosignals that are interpreted by several regions of the central nervous system.

Premature infant auditory function has been examined using animal models including kittens who, in the first 1 to 3 weeks of life are comparable to infants born 15 weeks early (Parmelee, 1981). The physical apparatus for audition in the premature infant is in place but the neural connections that provide for the interpretation and meaning of sound are in varying stages of development. The use of auditory evoked potentials have provided fundamentals of the developing auditory system and have been measured as early as 25 weeks gestation but are only reliable at 28 weeks (Parmelee, 1981). In general, brainstem auditory evoked responses of premature infants is reported to be similar in latency and waveform to term newborns by the time they reach term gestation. At 26 weeks there are long latencies and incomplete wave forms. Rapid improvement in evoked potentials is evident by 36 weeks gestation (Goldie, 1992). When differences are found they can be related to medical complications (Parmelee, 1981).

The auditory tract begins to function by 7 months gestation and is myelinated in a series of stages until 4 years of age (Aslin, et al., 1983b). The slow maturation of the auditory system presents a wide critical period in which the neurological system is plastic, or changeable and can profit from extended environmental experience (Berg & Berg, 1979). These facts lend support for the use of interventions involving sound to facilitate premature infant development since sensory input is an important aspect of perception and attention.

A model of perceptual processing that is dynamic and continuous captures the flow, continuity, and adaptability of an infant's acquisition of knowledge about the world (Haith, 1990). Sensory systems become mature and established early in life and require information to function properly involving both intrinsic and extrinsic factors for normal brain development. In general it appears that experience is necessary for normal auditory development. There is some evidence that experience plays a role in modifying perceptual categories for speech by making it more or less discriminable or shifting the boundaries of perception but the relationship is not entirely clear (Aslin, Pisoni, & Jusczk, 1983a).

Auditory abilities currently established for newborns include sound discrimination, localization, categorical, and temporal perception (Aslin, et al., 1983b; Berg & Berg, 1979; Clifton, Morrongiello, Kulig, & Dowd, 1981; Morrongiello & Clifton, 1984; Muir & Clifton, 1985; Zelaro, et al., 1991).

Auditory pattern recognition has been demonstrated in term infants under one month of age (Muir & Clifton, 1985). Thresholds for neural responses are limited to a restricted range of sound frequencies with lower frequencies developing first followed by higher frequencies with maturation (Berg & Berg, 1979). Although most established information is on older infants, frequency limens have been obtained as young as 5 months of age (Olsho, 1984) and more recently, it has been found that from that from the age of six weeks, infants are able to discriminate complex acoustic stimulation including speech (Olsho, Koch, Carter, Halpin, & Spetner, 1988). Thus at earlier ages, emerging abilities are being discovered. Perceptual factors such as attention and memory have been implicated as limiting factors in establishing infant auditory thresholds (Jusczyk, Bertoncini, & Bijeljac-Babic, 1990; Olsho, Koch, & Carter, 1988).

Most studies on speech perception have been done on infants over 6 months of age (Kuhl, 1985). Infants are able to make distinctions between vowel sounds and process speech intermodally (Kuhl & Meltzoff, 1984). Speech is processed through sensory (acoustic) and interpretive (phonetic) contexts. The capacity to discriminate phonetic components of speech appears to lie within newborns capacities (Mehler, Bertoncini, Barriere, & Jasssik-Gerschenfeld, 1978) as well as prosaic and temporal elements of speech sound (Gottlieb, 1985). Important dimensions of sound acoustics concern stimulus duration, repetition and rate (Clarkson, Clifton, Swain, & Perris, 1989). Infants seem to have sound preferences such as vocal to instrumental music (De Casper & Spence, 1991). Fundamental frequencies of adult females voices range from 150-350 Hz and are believed to be with in the frequency range most appealing to newborns (Gottlieb, 1985).

Premature infants pay greater attention to objects with sound while having difficulty differentiating multimodal stimuli (Lawson, et al., 1984; Ruff, 1986). Heightened responsiveness within the vocal and affective channels have been demonstrated. Visual attention and onset of infant gaze is more easily elicited by vocalization (Barratt, Roach, & Leavitt, 1992). Wide bandwidth sounds are more effective in eliciting responses in premature infants than narrow bandwidths (Clarkson & Clifton, 1991). Evaluations have shown that infants who were premature at the time of birth, turn to sound more often than full term infants, on at least 75% of trials, however preterm infants exhibit poor muscle tone, less spontaneous activity, and take significantly longer to complete a response (Muir & Clifton, 1985). Most studies have shown that premature infants tend to show long latencies in response and require slightly longer periods of exposure to sound and longer intervals in between trials (Karmel, et al., 1991; Lawson, et al., 1984; Ruff, 1986). They may respond better to more repetition, and longer disengagement periods to process information.

Human voice studies

Based on information that has been obtained from term newborns provided voice stimulation, it was speculated that responses may be similar for premature infants. Newborns are able to differentially respond, interact and actively seek contact with a wide range of maternal stimuli and respond to maternal affect and voice intonation (Fifer, 1987). A preference for maternal voice has been repeatedly demonstrated (De Casper & Spence, 1991;

Fifer, 1987; Hepper, Scott, & Shahidullah, 1993; Mehler, et al., 1978) as well as selective attending to maternal voice (De Casper & Spence, 1991; Gottlieb, 1985) when compared with voices of other women. This preference might serve as a way to facilitate the development of reciprocal interactions essential for the early stages of attachment.

Speech relevant acoustic properties of maternal voice can be detected and discriminated by fetuses by 32 weeks in utero and cardiac decelerations have been demonstrated by fetuses at this gestation (De Casper & Spence, 1991). A number of researchers have suggested that the sounds transmitted to the fetus are particularly biased toward experience with the dominant frequencies found in speech sounds (Aslin, et al., 1983b; Fifer, 1987; Rubel, 1985). Human fetus responses to acoustic stimuli with modulated states of alertness heart rate change as early as 28 weeks (Aslin, et al., 1983b). Most recent intrauterine recordings indicate that speech sounds to the fetus are minimally distorted. The intonation and melodic contour is identical to extrauterine voice and may be the critical factor in underlying subsequent postnatal responsiveness to voice (Fifer, 1987).

Recognition of mother's voice from others is demonstrated by increased prolonged bursts of sucking (Spence & Decasper, 1987). Infants also demonstrate synchronous changes of movement with adult speech (Symons & Moran, 1987). The adaptive value of exposure to voice is a relatively unexplored area for the premature infant.

Slightly older infants show a preference for "motherese" or infant-directed speech. Fundamental frequency has been shown to be the most salient factor in motherese for infants (Fernald & Kuhl, 1987). The frequency range of motherese is 100 Hz to 800 Hz compared to 100 Hz to 300 Hz in adult speech (Gottlieb, 1985). Tone inflection coveys messages of anger, joy, or sadness. Maternal voice inflection encourages emotional regulation and social competence. Some preliminary indications have suggested that premature infants are also responsive to motherese as mesured by a more prolonged time that infants were able to keep there eyes open during observations (Eckerman, Oehler, Medvin, & Hannan, 1994).

The early development of speech in infants has sometimes been compared to bird calls in various bird species. There is evidence that prenatal auditory experience plays a role in ducklings perceptual sensitivity to critical acoustic features of bird call. Specifically repetition, and frequency band have been identified as salient for the mallard and wood duck (Gottlieb, 1985). If muted duck embryos (those removed from sound exposure) are stimulated with recordings of the embryonic call, they develop a normal postnatal call preference and a species typical rate of development can be assured (Johnson, 1985). Like the unique acoustic properties of bird calls, infant-directed speech has an exaggerated pitch intonation and slow rhythm. Since animal models are frequently applied in the study of development, perhaps exposure of a premature infant to maternal voice can produce similar benefits.

Infants in neonatal intensive care units are exposed to a variety of sounds from both equipment and human voices. Incubators that house premature infants on average produce continuous motor noise at a level of 70 decibels (Parmalee & Sigman, 1983). Additional noises occur with banging of doors and alarms from monitoring devises. The noise in the NICU has been estimated by decibel comparison to be similar to heavy traffic (Thomas, 1989). Although multiple voices are heard, speech is seldom directed at the infants (Blackburn & Barnard, 1985). An auditory stimulus needs to be presented at an intensity level of at least 40 decibels to evoke a responses from premature infants that are 28 to 32 weeks gestation (Parmalee & Sigman 1983). By 34 weeks, premature infants have more varied and selective responses to sound such as decreased body activity, brightening of eyes and longer periods of alertness (Als, Lester, & Brazelton, 1979).

Only a few studies have involved human voice with premature infants. Specifics of these studies are listed in Table 1. The purpose and methods vary considerably. The exact procedures were inconsistently provided in most cases. A wide range of gestational ages suggests the infants were at different levels of development and medical stability. Some studies reported significant results but have combined voice with other types of stimuli or sounds, and used different outcome measures making results difficult to interpret.

Premature infants exposed to maternal voice have shown an increase in muscle tone and improved responsiveness (Katz, 1971). and improved weight gain (Malloy, 1979). Crying infants demonstrated heart rate deceleration in response to mother's voice (Segall, 1972). Results of these studies were based on exams prior to discharge and it is unclear if ongoing assessments were done during the intervention. In most cases the voice intervention seem to be used as a general stimulation to improve growth and motor development and frequently continued until hospital discharge. The immediate behavioral responses of the infants are not known. Behavioral reactions were not recorded during stimulus exposure. None of these studies used specific measures of attending to maternal voice.

The behavioral responses of premature infants to human voice have been investigated under conditions where mother's voice was not used. In a early initial study, Oehler and Eckerman (1988) examined 15 LBW infants of diverse ethnicity for response to female voice. The examiners achieved high interrater reliability in the observations demonstrating voice as an effective way to alert preterm infants. Infants born prematurely have repeatedly shown interest in vocalization, but poor attention seems to be a major intervening factor.

A large recent study further investigated responses of premature infants to human voice using female examiners (Eckerman & Oehler, 1994). Talk was provided in motherese in an en face position, and gradually included tactile stimulation in addition to talking. Approximately 3 minutes of talk, followed by 2 minutes of talk and touch together was provided. Three sets of coding behaviors were analyzed from videotapes. Infants responded to the motherese with increased visual attention. Arousal efforts were seen even in the high risk group. Addition of tactile stimulation however, led to decreased visual attention and increasing signs of distress. The younger the infants in gestation, the more aversive reactivity that was seen. This investigation delineates quite well the social demands placed on these early gestation infants which naturally occurs when mothers are "en face", talking, and touching their infants at the same time.

Limitations of these studies include confounding factors related to multimodal stimulation and infant tolerance. Specific effects of each type of

Table 1. **Human voice studies with preterm infants**

Investigator	Subjects	Procedure	Gestational age	Results
Katz, 1971	31 experimental 31 controls	starting at 5 days ending at 35 weeks tape of mother's voice x 5 mins, six times per day at 2 h intervals	28-32 weeks	Greater auditory and visual function at 36 weeks as measured by the Rosenblith
Segal, 1971	30 experimental 30 controls	mother 's voice 30 mins/day until 36 weeks	28-32 weeks	greater increase in heart rate when quiet/exposed to white noise heart rate decreased with mother's voice when crying
Chapman, 1979	50 experimental 1 51 experimental 2 52 controls	E1's taped mother's voice E2's taped brahm's lullaby starting at day 5, continuing to 1800 gms	26-33 weeks	E2 had faster weight gain than E1 No difference in limb movements

Table 1. continued

Malloy, 1979	40 Experimental 1 44 Experimental 2 43 controls	replicated Chapman's study	26-33 weeks	E1 and E2 discharged 6-9 days sooner than controls E's had lower Bayley scores at 9 mos
Oehler et al., 1988	15 VLBW infants	Counter balanced protocol-midway between feeds: Talk, Stroke, Talk/Stroke started on 1st or 2nd week of life	30-34 weeks	Talk produced visual attention Stroke increased motor activity Talk/Stroke produced motor disorganization
Eckerman et al, 1994	LR (low risk)=96 HR (high risk)=68	3 counter balanced protocols for 3 consecutive days: Quiet, Talk, Talk/ Touch	29-36 weeks	Both groups displayed visual attention to motherese. Poor tolerance of HR group to touch/talk More distress in HR group

stimulation can only be determined if they are provided and measured separately. Beneficial effects of one type of stimuli may be counteracted or masked by one that is not positively received. In addition some of the infants in the Eckerman et al. (1994) study were unstable enough to delay procedures until they reached 33 weeks gestation and as a result chronological ages varied. There were no exclusion criteria reported which indicates the neurological status of the infants probably also varied quite a bit. Immediate responses of preterm infants to maternal voice has not been studied by any of these groups. There is currently very little information available concerning the quality of responses to stimulation at different gestational ages or the patterns of responses that emerge. It is important to establish the effects of any intervention with preterm infants and it is therefore necessary for a closer examination of what infants actually do at the specific time of exposure.

Salience of human speech for preterm infants in everyday interactions may be related to intrauterine experience with maternal speech (De Casper & Spence, 1991). Cohen (1995) has stated "the single variable that has been shown to be most associated with cognitive outcomes is the amount of talking to the infant by the primary caregiver". Talking to premature infants has been shown to aide in maintaining or achieving a motorically quiet, visually attentive behavioral state (Oehler, et al., 1988). Talk seems to quiet infants who were already aroused and to arouse infants who were sleeping. Since talk has been observed to promote some stabilization of an attentive state, particularly if mother's voice is used, this suggests that mother's voice should be examined for therapeutic benefits.

Issues of Measurement

Measuring Responses to Sound

Two areas remain a problem for use of auditory stimulation. The auditory system is devoid of unique behavioral responses, in that there are no specific indexes of auditory function in humans. Second, specification of auditory stimulation used in past research has been ignored with a variety of sounds being used including bells, clicks, buzzers, rattles as well as voices making it difficult to interpret results. In order to examine attention and responsiveness, it is imperative that the sound not be frightening or aversive to the infant. High frequency sounds for instance, have been noted to produce defensive responses (Eisenberg, 1970).

Preterm infants seem to have an elevated sensory threshold which functions protectively (Rose, 1983). Once a stimulus is sufficient enough to elicit a response, efforts to prevent overwhelming the infant must be a priority. Determining the optimal range of responsivity is therefore difficult. The methods currently used to study auditory responses include 1) gross motor activity, 2) change in respiration rate, 4) cardiac responses 3) oculomotor responses, 4) inhibition of behavior, 5) high amplitude sucking, 6) head turning 7) visual reinforced head turning (Aslin, et al., 1983b; Jusczyk, 1985; Kuhl, 1985). In the newborn period, the most widely used method is high amplitude sucking (Jusczyk, 1985). Unfortunately most of these techniques are not appropriate for a premature infant. A continuing issue is the absence of a measurement technique that can be used with infants of varying ages. Premature infants in early gestations are unable to turn their heads and have poorly sustained sucking ability. Measurements which established important information for newborns such as high amplitude sucking and head turning are difficult to use in premature infants due to poor muscular and motor development.

The auditory system is structurally in place by 24 weeks with cortical connections increasing with gestation. Premature infants are sensitive to sound and have been found to be particularly responsive to vocal stimulation (Barratt, et al., 1992; Ruff, 1986; van Beek, Hopkins, & Hoeksma, 1994). To measure response to maternal voice, there are 3 possible mechanisms that may be used in premature infants: heart rate, behavior, and infant state. Although limited, early information in cardiac responses and behavior provides some comparison. These alternative measures have been used with this group of infants with varying degrees of success. The behavior of an any infant is an important route of communication and characteristic behaviors that are produced by premature infants have been identified and quantified (Als, Duffy, & McAnulty, 1988). Cardiac and behavioral responses to repeated exposure to maternal voice may be described in terms of readiness to be aroused, sensory maintenance of arousal, presence and/or ease in which the response was inhibited. In addition effects of maternal voice over time on state regulation and periods of alertness can be explored.

Measurement of heart rate and infant state

Measurement of heart rate and state dependent variables in newborns have shown that both these factors are intimately involved with stimulus effects (Berg & Berg, 1979). The autonomic nervous system reacts to novel, intense stimuli and is quite responsive to environmental changes (Von Bargen, 1983). Autonomic changes have been useful correlates of information concerning memory, attention, and learning (Lipsitt, 1990; Olson & Sherman, 1983). In the newborn period, the occurrence of decelerative cardiac orienting to a stimulus occurs by apparently eliciting the neonate's attention. Stilling or decreased activity is another aspect of attention. Motor activity may influence both the direction and magnitude of heart rate response of young infants with increased motor activity usually producing cardiac acceleration. Moreover, cardiac change can indicate attention to sound in the absence of an overt behavioral response. (Morrongiello & Clifton, 1984) .

A number of unequivocal studies have demonstrated sustained deceleration in term neonates to stimulation from a variety of modalities (Berg & Berg, 1979; Clarkson & Clifton, 1991). Investigations have used infant heart rate to index sequential phases of attention such as sustained attention, as well as stimulus orienting and attentional termination (Richards & Casey, 1991). Infants most often display processing of information by heart rate deceleration. Heart rate may however, increase slightly and then returns to baseline during the attention termination (Clarkson & Clifton, 1991). A refractory period in attention has also been demonstrated by an attenuation in heart rate deceleration during the stimulus onset, suggesting either inhibition of attention for processing information or inability to engage (Richards & Casey, 1991).

Orienting responses have been demonstrated inconsistently in premature infants. Heart rate is fixed and unvaried prior to 28 weeks with early pattern changes noted around 30 weeks (Parmelee, 1981). Since cardiac responses are not easily obtained, they may be present but not seen. During the newborn period there is a predominance of sympathetic control of the heart and prominent vagus nerve sensitivity which seems to be age-related. In addition, heart rate variability is more evident with age (Porges, 1983). Premature infants have a higher resting heart rate than full terms and therefore stable baseline measures are essential. Less heart rate reactivity has been shown in premature infants as well as little cardiac habituation to repeated stimuli (Field, Dempsey, Hatch, Ting, & Clifton, 1979).

Using auditory stimulation, some differential responses have been found when low and high risk groups are compared. Low risk premature infants (those who are over 30 weeks and have minimal or no complications) showed clear deceleration, but higher risk infants (prolonged illness, early gestation) displayed initial heart rate acceleration with responses changing to decelerations at about 35 weeks gestation. On repeated trials, there has been an eventual response in initially unresponsive premature infants (Schulman, 1969; Stamps, 1978). By exposing infants to a stimulus on more than one occasion, it may be possible to demonstrate responses over time, even if there is no cardiac orienting evident on the initial trial. In addition, cardiac responses are sensitive to infant state. Transient periods of alertness attenuate but do not eliminate deceleration (Berg & Berg, 1979). Premature infants with less state control frequently drift in and out of a quiet alert state, and when present it is usually brief, indicating that establishing a decelerative response may be difficult in these infants. Other stimulation studies have demonstrated that when a more intense stimulus was used, cardiac responsivity was obtained that was similar to term infants implying that sensation was more of an issue than effort (Field, et al., 1979). All of these findings indicate that patterns of responses of premature infants require further study.

Another pattern infants may display is cardiac orienting without evidence of cardiac change or response recovery to the novel stimuli (Fox & Lewis, 1983). This suggests that the specific pattern of cardiac responsiveness may be individual or may be different for premature infants in general due to the level of maturity of the autonomic nervous system control.

Field (1979) as well as others have found that premature infants are unable to habituate to repeated presentations of stimulation. An infant who cannot ignore redundant input is at the mercy of external stimuli and this is extremely costly to homeostasis. Carefully controlled stimuli may gradually produce habituation and foster self regulation in these infants.

Krafchuk et al (1983) examined 3 groups of infants ranging in gestation from 38-40 weeks, 31 to 35 weeks and to 28 to 30 weeks (premature infants were tested at 39-38 weeks conceptual age) for cardiac reactivity. Sound was presented using a tape recording of a rattle (3-to 4 shakes) for 10 trials of 36 second intervals. The rattle was followed by a dishabituation mechanism eliciting a moro reflex and then 4 subsequent trials. A significant finding during the stimulation was a biphasic response of cardiac acceleration followed by deceleration below baseline in premature infants. Heart rate consistently showed signs of cardiac acceleration during dishabituation.

Some questions remain on whether cardiac activation is actually smaller or if the shift upward is obscured in premature infants by the high resting heart rate. In functional auditory studies without intervention, performance of heart reactivity is uniformly poorer even with corrected gestational age and similar SES variables. Delays exceed what would be expected by physiologic maturity alone.

In terms of attention and arousal to auditory stimulation, pure tones are less effective than multifrequency sounds. Variations in frequency, bandwidth, and intensity are important in the determination of responsivity (Berg & Berg, 1979). Responses are greater to pulsed rather than continuous stimulation (Bohlin, Lindhagen, & Hagekull, 1981). The processing of temporal transitions has been suggested to improve infant attention to auditory stimulation. Intonation patterns may be the most salient aspect of maternal speech (Gottlieb, 1985). The optimal intensity level to changes in heart rate is 62 dB--the average intensity of normal speech. This would indicate that maternal voice is potentially a good stimulus to promote an attentive state in an infant.

An aspect important to infant attentiveness to stimuli is infant state. Normal CNS maturation is characterized by a decrease in ratio of active sleep to deep sleep as an infant grows (Berg & Berg, 1979). The amount of active sleep in turn is regulated by the amount of time in attentive observation of the environment. This has been demonstrated in studies that found reduced amounts of active sleep in infants who had the longest periods of visual fixation (Berg & Berg, 1979). It has been shown that when premature infants are with their mothers they are awake most of the time and when left alone, they spend 82% of their time asleep (Becker & Thoman, 1983). Considering the fact that chronologically these infants are 2- 3 months old, one would anticipate that longer awake periods would be emerging. Appropriate stimulus intervention may influence state regulation resulting in increased availability for interactive processes. Behavioral state reflects recurrent cyclical changes within the nervous system (Becker & Thoman, 1983).

Multimodal stimulation has demonstrated improvements of state regulation in premature infants. Nonnutritive sucking is particularly effective (Anderson, Boroughs, & Measels, 1983; McCain, 1992) as well as some forms of tactile stimuli such as stroking (Rice, 1977; Scafidi, Field, Schanberg, Bauer, Bega-Lahr, Garcia, et al., 1986; White & Labarba, 1976). Using a rocking bed, and recorded heart beat sounds together resulted in accelerated state regulation and increase in length of quiet sleep in an early study by Barnard (1973). Using a tape recorded human heart beat during sleep, Rose et al (1976) found that the rhythmic stimulation had substantial benefits on sleep states, motility patterns, and resulted in behavioral responsiveness similar to fullterm infants.

Another measure of stability that is routinely used with premature infants is oxygen saturation which can be measured non-invasively with pulseoximetry. For the purpose of this study, the additional measurement of oxygen saturation was thought to be a potential indicator for determining the presence of distress. Good correlations have been establish with arterial saturation levels and readings are instantaneous (Barrington, Chb, Finer, & Ryan, 1988).

Any intervention with a premature infant must take into account the limited ability of the infant to mobilize a dramatic response as well as immature somatic and autonomic regulation. Poor motor inhibitory responses, weak musculature, poorly organized sleep states, and difficulty maintaining levels of alertness may result in an inadequate response to stimuli. Through extensive work, behaviors have been identified that can be categorized as approach or avoidance behaviors in premature infants which have helped to determine the effects of handling and stimulation (Als, 1986). The relationship between neural and perceptual events requires behavioral assessment. Behavior coupled with heart rate reactivity under conditions of repeated measures, may help to establish a pattern of responses.

Since the auditory system is fairly well developed early in gestation, and a preference for maternal voice has been established as well as the appropriateness of the acoustic properties of human speech, exposure to maternal voice may have potential to mitigate the less than optimal outcomes frequently found in this population. Maternal voice stimulation offers unique qualities that may bridge the gap between intrauterine and extrauterine life.

The full capabilities of premature infants have yet to be identified. There is a over-reliance on full term models and even most premature infants are not studied until they reach term age or older which gives little insight into the process of their early development and function. Data on specific infant responses or boundaries of tolerance is currently insufficient as well as appropriate parameters for the use of stimulation. Infants born prematurely may be already accumulating auditory deficits which will influence their intellectual and cognitive development. Determining ways to facilitate optimal development of premature infants during the period between birth and expected date of birth should be a focus of intervention programs (Vohr, 1991).

CHAPTER III: Methodology

Study Design

The current study was a quasi experimental, within subject, repeated measures design using a small sample. The purpose of this research was to describe the effects of taped maternal voice on the behavioral and physiologic responses of stable premature infants studied during the first week of life. The research aims included determining whether taped maternal voice would produce stressful behavior, and whether the infant responses would change with repeated exposure.

Small sample research helps to determine the pattern of responses by examining the variations in the data of each subject (Mitchell, 1988). It is particularly helpful in highly variable, heterogeneous groups such as premature infants, for which there is minimal current knowledge. In addition to a high level of variability among premature infants, measurable responses may not always be seen. Due to the exploratory nature of this research and the characteristics of this population, this type of design is likely to yield the most valuable information.

Sample

A purposive sample of premature infants between 28.1 and 35.9 weeks gestation was chosen for study. Gestational age was determined by ultrasound in the early stages of the pregnancy as reported in the medical record. Study subjects were obtained from two Level II Special Care Nurseries in the greater Seattle area. In the course of the study, three infants were obtained at one site, the other 11 study infant came from the second site.

Inclusion criteria

Infants who met the following inclusion criteria were included in the study: 1) Nonventilated premature infants between 28.1 and 35.9 weeks gestation, 2) cared for in incubators, 3) less than one week of age at time of entry into study, 4) maternal age of at least 18 years and 5) parental consent was obtained (Appendix A).

Exclusion criteria

Infants with the following conditions were excluded from the study: 1) known neurological or congenital defects, 2) exposure to cardiogenic drugs such as dopamine or muscle relaxants, 3) maternal history of drug use, and 4) greater than grade II intraventricular hemorrhage on cranial ultrasound. These infants were not considered eligible because of the potential for these factors to influence behavior and heart rate.

Independent Variable

The stimulus used in this research was a tape recording of mother's voice. All of the mothers were asked to read the same children's story to their infant which was tape recorded to produce three minutes of maternal voice for use in the study. On the Day You were Born by Debra Frasier (1991) was the book which provided the content of the tape. Speech produces an intensity level normally ranging within 60 to 70 dB. All maternal voice tapes were examined for clarity prior to use and sound level was established and maintained at no greater than 70 dB to coincide with the level of the normal speaking voice.

Infants were exposed to the independent variable 12 times (four sessions per day for three consecutive days). Each nine minute session involved three minutes of baseline data collection, followed by the three minutes of tape recording of maternal voice. The tape was then followed by three minutes of post intervention data collection.

Dependent Variables

Behavioral data

The infants were videotaped to capture their behavioral responses and recorded continuously at each data collection period. A minimum of nine minutes of video tape was obtained for each session of the study. The six major categories of behavior used were activity, state, visceral responses, motor responses, facial responses, and attentive responses. Each category included up to 9 different behaviors that were coded as present or absent. Behaviors indicating either modulation (e. g., smooth movements, relaxed face, hand clasp) or distress (e. g., arching, finger splays) as described by Als (1986) were included, as well as facial expressions and visceral responses. These definitions are listed in Appendix B. These defining characteristics are specific to the level of immaturity seen in premature infants and are items included on established assessments such as the Neonatal Individualized Developmental Care Assessment Program (NIDCAP) observation tool. These tools were developed after years of observing premature infant behavior and have been used in numerous studies (Als, Lawhon, Duffy, McAnulty, Gibes-Grossman, & Blickman, 1994) The eight point Blackburn Activity Scale for Premature Infants (Appendix C) was used to code the level of activity based on gross motor movements (Blackburn & Patteson, 1991). This categorical scale indicates a range from no facial or body activity to intense trunk movement (writhing or thrashing) and has also been used to describe activity responses in previous studies involving premature infants. The scale was developed from multiple hours of videotapes of preterm infants.

Infant states were determined and recorded according to the expanded descriptions for premature infants as defined by Als (1986). Infants states range from deep sleep to crying and have six categories. Appendix D list the infant state codes.

Observable indicators of attention were also coded as present or absent and were derived from The Brazelton Neonatal Assessment Scale (Brazelton, 1995) as well as the NIDCAP tool (Als, 1982).

Physiologic data

Physiologic data consisting of heart rate, respiration and oxygen saturation were continuously recorded throughout each of the data sessions. The data were time synchronized at 10 second intervals to coincide with the behavioral variables.

Clinical Data

Demographic information was recorded on a form designed for this study (Appendix E). These variables include gestational age a birth, age in days at time of study, birth weight, and Apgar scores. Perinatal variables consist of maternal age, parity, gravity, and pertinent pregnancy labor and delivery information. Field notes were kept via a clinical data sheet (Appendix F) to determine other factors within the environment that may have affected the results and include factors such as necessary procedures as well as visiting schedules of parents and current medical support (oxygen, medications, feeding profiles).

Human Subjects

Approval for the study of human subjects was obtained from the University of Washington and participating hospitals. Parental consent was obtained prior to data collection (Appendix A). All information was kept confidential and all subjects were assigned code numbers. All of the data were collected and stored by the investigator.

Instrumentation

Equipment

Infants were videotaped with a mini camera made by Toshiba, (Model # IK M30 AK, Torrance, Ca). interfaced with a high resolution television monitor (Panasonic, Model # CT 138-34) and recording device (Model AG 6030-P, Seattle, WA.). The camera was mounted at an inside corner of the incubator and remain in place for the duration of the data collection period with removal at the end of each day.

Heart rate and oxygen saturation were obtained concurrently from a SpaceLabs Data Master PC (Redmond, WA, Model # 90305) and stored on computer discs. Silver-silver chloride infant cardiac electrodes were consistently placed and provided a digitally displayed signal that was averaged over 3 seconds. These signals were analog converted for storage at 10 second intervals in the SpaceLabs PC monitor (Spacelabs, Redmond WA.). The SpaceLabs monitor simultaneously recorded and displayed oxygen saturation with the use of a photo optic oxisensor probe. Pulse oximetry readings are instantaneous and were obtained at the same rate. A good correlation between arterial and transcutaneous oxygen saturation in neonates has been established ($r=0.90$, $p<0.001$) (Jennis & Peabody, 1987).

All physiologic monitoring instruments had satisfactory reliability scores and concurrent criterion validity both prior to commercial release and were tested by the biomedical department at the study locations. At the onset of the study, the monitor was calibrated against the reference value established by the National Bureau of Standards Lab in Washington D. C. All instruments automatically self-calibrated to an accuracy of within two beats per minute prior to each data collection. The signal bandwidth for infant QRS. detection was .5 to 40 Hz with an amplitude of 0.15 to 5.0 mV. The monitoring system provided a range of signal bandwidths of .05 to 100 Hz to eliminate respiratory and motion artifact at low frequencies and 60 cycle alternating current and muscle artifact at high frequencies. The physiologic parameters were updated and digitally displayed every 3 seconds. The physiologic data were collected in 10 second mean epoch values to coincide with the behavioral coding data. This frequency was chosen to reasonably manage the large volume of data that was generated. The video recordings were time stamped and synchronized with the recording of physiologic data.

A tape recorder (Sony Model # WM-D3, Tokyo, Japan) was used to provide the taped message and was located outside the incubator. A small sponge-tipped insert earphone (Etymotic Research, Elk Grove, Ill #ER-3A) with a small transducer was used to deliver the taped recorded voice. The earphone was placed over the infant's external ear canal. All equipment was kept on a rolling cart that was moved to the bedside area for data collection and then easily removed to another area for storage.

Data Collection

Pilot Data

A pilot study was conducted to test equipment and to determine the final study procedure. This research was designed to be conducted in the special care nursery while the infants were in incubators. Data obtained from observing three pilot infants helped to finalize the frequency and duration of the intervention. It also gave an indication of the clinical settings and activity level of the environment. In the pilot study, data collection on the infants began after they received their usual care including feeding. The major change made after the pilot study was to collect the data prior to caregiving intervals. The infants in the pilot study observed after a care episode were found to be tired and sleepy. It was decided based on this experience that measurements would be taken at a scheduled care time, but prior to feeding and handling. Since different caregivers took varying amounts of time to take vital signs, provide a feeding, etc., the change provided more systematic control for keeping the data collection time frames uniform.

Procedure

The infants' current care schedule, which was the time the nurses took vital signs and provided treatments and feedings, was chosen as the time interval for the intervention. Since there are no established parameters for appropriate timing for introducing stimuli, this time frame was chosen for three reasons. The first reason was to avoid disturbing the infant's rest. Frequent disruptions add to the disorganization of premature infant behavior (Als, et al., 1988; Blackburn & Barnard, 1985; Lawhon & Melzar, 1988). The second reason was to minimize inconvenience to the nursing staff, and third, to attempt to capture the times when the infant was most likely to be awake. The data were collected approximately 30 minutes prior to the scheduled nursing care. Infant state was not controlled in this study. The sessions were conducted at the infant's specific care interval regardless of whether the infant was awake. Premature infants spend the majority of their time in active sleep with only brief periods of quiet wakefulness (Holditch Davis & Thoman, 1987). It would have required examiner manipulation to achieve an awake state prior to introducing the voice.

The length of the tape was three minutes and therefore each period of measurement was three minutes in length. This length was chosen so that the infants would not loose interest and to prevent overstimulation. Since the infants already had cardiac electrodes in place and most were monitored for oxygen saturation, there was minimal manipulation required. All procedures were conducted by the researcher.

The infants served as their own controls in the following manner: baseline measures (three minutes) were established for each session, followed by a period of exposure to maternal voice (three minutes), after which post-intervention measures were obtained (three minutes). The A-B-A design, allows for a comparison of the dependent variables where the baseline phase (A1) is repeated (A2) at the end of the intervention (B) allowing conclusions to be made that the changes measured during the treatment phases were most likely a function of the treatment (Hersen & Barlow, 1984). Infants were continuously recorded from the beginning of the baseline phase to the end of the post intervention phase. Each 9 minute session was conducted a total of four times each day for three consecutive days. There has been suggestion from past research, that premature infants need several stimulus trials in order to display a response. It was thought that perhaps the infants might show signs of familiarity by the end of the third day.

Women admitted to the perinatal center who delivered infants who met the inclusion criteria were informed about the study by a hospital intermediary. If the mother indicated a desire to participate, a complete description of the study was provided by the primary investigator and written consent for participation was obtained. Each infant's mother read the same children's story which was recorded in her voice on a tape cassette. Since the mothers read at varying speeds, some of the tapes were not exactly three minutes in length. To remedy this problem, the mothers was asked to read for at least three minutes, and then during the study sessions the tape was stopped after three minutes.

The data collection period began after the first 48 hours of life and prior to seven days of age. This early period of time was chosen for study in order to capture premature infant behavior when the infants were actually at the gestation they were born. The first two days of life were excluded to allow the child some time to equilibrate to the extrauterine environment. Information about premature infants so soon after delivery has rarely previously been obtained. It was hoped that not only would something new be learned, but also this study would give an indication of premature infant behavior without the confounding factor of maturation.

After assuring time synchronization of the video recorder and the physiologic equipment, the tape recorder was checked with a sound level meter. The decibel level of the tape was kept at an average range of 65 dB.

The cables from the infant's monitoring devises were switched to the study monitor. Contact with infant generally consisted of positioning the ear probe over the infant's ear and placing the infant in line with the camera. All other equipment manipulations occurred away from the infant. Some infants were fussy and were briefly given a pacifier and a diaper change prior to beginning the baseline period.

The sequence for data collection proceeded in the following fashion. The computer was programmed to collect the physiologic data. The video recorder was started. After baseline measures were obtained, the tape recorder was turned on and then stopped after three minutes of play. The observation continued through the three minute post phase. At the end of the videotaped session, the ear probe was removed, and the infant was returned to his or her own monitor. No further recording was done until the next care interval. Each session was conducted consecutively for four times each day. The average time between sessions was three hours. This varied slightly with the infants care needs. However, there were several hours between the last session of each day and the first session of the following day. The duration of the study was three days. Every attempt was made to keep to the sessions at similar times each day.

Data Management

Behavioral data

The behavioral responses were coded from videotapes utilizing the Coder 2 computer program supported by the MacArthur Foundation Research Network. Behavioral responses were coded at ten second intervals from video tapes transferred to the Coder 2 (Arvid Kappas, 1992) computer program specifically designed for use in infants. All video tapes were VITC (vertical interval time code) coded for use in the Coder 2 program to provide time synchronization. The VITC codes are established by a vertical time code method (VTC) that records the address of each frame within the video image and is not visible to the human eye. The time codes are precise to a fraction of a second. The data from the Coder 2 is time stamped and LED displayed to a thirtieth of a second accuracy. The behavioral data files were ultimately transferred to ASCII files. The specific time interval of the three segments (baseline, tape and post tape) were extracted from the data. These files were then combined with the physiologic data files for comparative analysis. Subject 5 had missing behavioral data for one of the 12 sessions. All of the tapes were coded by the researcher. Intrarater reliability as well as interrater reliability was established. Both the researcher and the second observer are certified in the administration of the NIDCAP scale from which the majority of the behavioral variables were adapted. Intrarater reliability was established on 10% of the tapes randomly selected from each subject at 94% agreement. Interrater reliability was also conducted and established at 91% agreement. Cohen's Kappa is a statistic used to determine interrater reliably that corrects for chance. The Kappa level obtained for interrrater reliability in this investigation was .81. The Kappa level for intrarater reliability was .91.

Physiologic Data

All physiologic data were stored on floppy disks and reviewed in detail. Missing values due to infant movement or artifact were replaced by averaging the previous and subsequent values. The data were transferred to ASCII files.

Analysis

Descriptive statistics were obtained including means, standard deviation, variance, and frequency on each variable for the 14 study infants. The data were analyzed in 10 second intervals for relevant information by the software programs SAS (Statistical Analysis System) and Statistical Program for Social Sciences (SPSS). Exploratory graphics were generated for visual inspection on each of the study infants. Data were inspected for changes in means, trends, level and frequency encompassing both magnitude and rate dimensions. The graphic visualization enables the differences in phases to be evident in this type of data (Kazdin, 1982).

Difference scores were used to compare each infant's responses in the pre-intervention segments with the taped and post-intervention segments. Repeated Measures MANOVA was used to examine the differences between and within infants. The segment means for the study sample were compared with paired t-tests. The temporal relationships of the dependent variables was not explored since the detected change was small.

CHAPTER IV: Results

The purpose of this study was to describe the behavioral and physiologic responses of premature infants to taped maternal voice. The research questions addressed were to describe: 1). the immediate effects of taped maternal voice on the behavioral and physiologic responses of premature infants, 2). the pattern of behavioral and physiologic responses with repeated exposure to taped maternal voice; and 3). the effect of infant state on the responses of premature infants to taped maternal voice.

The study infants were analyzed individually using pattern analysis and difference scores. Difference scores were determined on all infants between the three study conditions: a baseline segment, a tape segment and a post tape segment. Each of the segments analyzed were three minutes in length. The data were collected continuously during each session and repeated four times over each of the three study days. Since the data for each infant were serially dependent, the segment means were used for the analysis. Each infant was examined for all of the study variables over the 12 sessions using ANOVA to compare the mean values. None of the infants responses were significantly different from one another. It was not possible to detect significant differences for individual infants responses across the study sessions. For this reason, the sessions were combined to analyze the effects of maternal voice. Paired t-tests were performed to compare the 14 study infants as a group for differences across the three study conditions and across time. The level of significance chosen for analysis was .05 for two-tailed tests. Each variable will be discussed separately followed by a summary of the findings.

Description of Sample

The sample consisted of 14 nonventilated premature infants who were at least 48 hours old, but under 7 days of age when admitted to the study. There were 8 male infants (57%) and 6 female infants (43%). The infants ranged from 31 to 34 weeks gestation with a mean gestation of 33 weeks (SD = 1.01). The infants birth weights ranged from 1658 gms to 2885 gms with a mean of 2059 gms (SD=319.41). The demographic information for the sample is depicted in Table 2. The mothers of the infants ranged from 21 to 41 years of age (Table 2).

The clinical status of the sample was typical for infants born prematurely without significant respiratory distress. In general, infants had initial intravenous (IV) hydration after delivery and most infants continued with IV therapy during the time that feedings were gradually introduced. The infants were all briefly in oxygen therapy which was discontinued by the time of the data collection. All of the infants received antibiotics. Twelve infants required phototherapy. All infants but two had an IV in place when entered into the study. Five infants were given caffeine for apnea of prematurity. Subjects 2, 4, and 10 started on caffeine on the second day of data collection.

A variety of feeding methods were used with two infants receiving continuous feedings on an infusion pump. The most common feeding method was intermittent gavage (n=7). One infant was on all oral feeds and three infants were receiving a combination of oral and gavage feeds. Two infants were not fed. The infants were all housed in incubators for the

Table 2. Description of the Sample

n=14	Mean	SD	Minimum	Maximum
gestational age (wks)	33.07	1.01	31.00	34.00
weight (gms)	2059	319.41	1658	2885
maternal age (yrs)	30.14	6.09	21	41
maternal education (yrs)	13	2.02	12	17
paternal education (yrs)	13	2.96	9	13

duration of the study. Table 3 depicts the clinical data for infants on the first study day and the subsequent changes during the 3 days of data collection.

Physiologic variables

The mean values and ranges for each individual subject for all the physiologic variables are listed in Table 4. These tables are broken down by both session and segment.

The infants were examined for changes and patterns of heart rate, respiratory rate and oxygen saturation. In addition, an immediate change in response was investigated at the onset of the tape recorded voice to determine an orienting response. The heart rate and respiratory rate both decreased during the tape in 57% of the infants. Twenty nine percent of the infants had a heart rate increase with a decreased respiratory rate. Only two infants had a decrease in oxygen saturation of one percentage point during the tape segment. The mean change scores for each session for the physiologic variables are graphically represented in Figures 1-3. All figures presented display mean values within a 95% confidence interval.

Heart rate

The mean heart rate for the sample for all sessions was 141.53 BPM (SD=19.91). The infants' heart rate ranged from 62 BPM to 225 BPM over all of the sessions. The mean heart rate values during each of the segments across the 12 sessions for each infant are listed in Tables 4. The change in heart rate during the 3 segments was not significantly different over the 12 sessions for the total sample baseline ($\bar{X}$=141.83; SD=19.77) tape ($\bar{X}$=141.77; SD=19.42 and post tape ($\bar{X}$=140.98; SD=20.51). T-tests for the three study conditions are listed in Tables 5=7. When individual infants were examined,

Table 3. Clinical Data for Subjects on Entry to the Study

Infant	Weight (grams)	IV	Photo-therapy	Feeding type	Changes over study
1	2110	yes	yes	gavage	none
2	1675	yes	yes	NPO	temp unstable apnea
3	1788	yes	yes	gavage/ oral	none
4	1855	yes	yes	gavage	apnea
5	2815	yes	no	gavage	oral feeds
6	1740	no	no	gavage	none
7	2340	yes	yes	gavage/ oral	photo-therapy off
8	1620	yes	yes	gavage	none
9	2019	yes	yes	gavage	none
10	2115	yes	yes	NPO	feeds apnea
11	1627	yes	yes	contin-uous	none
12	1721	yes	yes	contin-uous	none
13	1772	yes	yes	gavage	NPO antibiotic apnea NEC
14	1860	no	no	oral	none

NPO=not feeding. NEC=necrotizing enterocolitis. gavage=tube feeding. IV=intravenous therapy.

Table 4. Physiologic Variables by Segment for All Subjects

Subject	Segment		Heart rate	Respiratory rate	% O2 Saturation
all infants	baseline	mean	141.83	35.46	97.65
		SD	19.77	15.37	2.45
		range	91-204	4-104	87-100
	tape	mean	141.77	34.48	97.58
		SD	19.42	15.53	2.36
		range	81-225	10-99	87-100
	post	mean	140.98	35.74	97.55
		SD	20.51	15.22	2.28
		range	62-204	10-106	87-100
1	baseline	mean	149.40	30.87	98.33
		SD	10.87	11.74	1.93
		range	116-184	13-72	87-100
	tape	mean	150.56	29.40	98.52
		SD	12.69	12.15	1.53
		range	103-194	9-75	92-100
	post tape	mean	151.34	30.30	98.10
		SD	15.00	13.05	2.13
		range	128-200	8-82	92-100
2	baseline	mean	142.98	46.21	98.76
		SD	15.27	15.63	1.23
		range	107-185	10-93	94-100
	tape	mean	144.18	42.53	98.64
		SD	16.56	16.61	1.36
		range	103-188	15-90	94-100
	post tape	mean	145.86	41.90	98.72
		SD	17.08	15.60	1.31
		range	115-194	10-99	94-100

Table 4 continued.

Subject	Segment		Heart rate	Respiratory rate	%O2 Saturation
3	baseline	mean	146.49	35.51	96.86
		SD	13.91	15.35	2.21
		range	101-197	9-81	94-100
	tape	mean	142.14	33.73	96.23
		SD	12.62	16.20	2.33
		range	81-185	9-97	88-100
	post tape	mean	141.40	34.63	98.86
		SD	12.15	13.57	1.98
		range	99-175	10-79	91-100
4	baseline	mean	143.29	34.23	98.63
		SD	11.31	15.16	4.38
		range	107-173	9-98	91-100
	tape	mean	149.10	32.21	99.31
		SD	14.46	15.21	.86
		range	109-186	11-89	96-100
	post tape	mean	148.34	36.66	99.02
		SD	16.54	15.44	1.12
		range	118-196	11-88	95-100
5	baseline	mean	133.71	32.72	94.63
		SD	13.13	12.71	2.47
		range	105-176	10-72	89-99
	tape	mean	131.97	31.87	94.43
		SD	12.83	12.33	2.57
		range	107-178	10-76	87-99
		mean	132.62	34.82	94.75
	post tape	SD	13.91	12.99	2.52
		range	100-175	12-76	89-99

Table 4 continued.

Subject	Segment		Heart rate	Respiratory rate	%O2 Saturation
6	baseline	mean	145.31	30.55	98.48
		SD	18.73	12.84	1.42
		range	101-196	10-86	94-100
	tape	mean	140.46	32.11	98.48
		SD	17.92	13.98	1.42
		range	101-186	10-86	94-100
	post tape	mean	136.33	30.62	98.48
		SD	16.11	12.57	1.43
		range	103-183	12-80	92-100
7	baseline	mean	133.76	30.79	95.89
		SD	18.41	14.72	2.57
		range	91-172	9-74	87-100
	tape	mean	134.58	29.07	95.71
		SD	19.69	13.71	2.89
		range	88-173	8-89	87-100
	post tape	mean	132.20	28.96	95.58
		SD	19.16	12.79	2.05
		range	90-174	4-84	87-100
8	baseline	mean	153.29.	37.24	97.64
		SD	25.01	16.66	1.33
		range	105-201	12-91	94-100
	tape	mean	153.81	39.85	97.50
		SD	21.29	17.27	1.43
		range	109-199	11-94	92-100
		mean	149.81	38.35	97.21
	post tape	SD	22.33	17.86	1.64
		range	106-201	11-93	92-100

Table 4 continued.

Subject	Segment		Heart rate	Respiratory rate	%O_2 Saturation
9	baseline	mean	143.30	34.41	98.91
		SD	19.92	14.71	1.09
		range	102-195	10-91	95-100
	tape	mean	140.45	36.65	98.94
		SD	21.03	16.23	.97
		range	94-198	10-99	95-100
	post tape	mean	137.62	36.79	98.98
		SD	21.07	13.68	.10
		range	97-204	13-80	94-100
10	baseline	mean	133.34	37.90	98.90
		SD	17.10	16.37	.78
		range	91-174	9-86	96-100
	tape	mean	137.33	37.50	98.73
		SD	16.42	17.46	1.19
		range	99-181	13-99	94-100
	post tape	mean	137.11	38.87	98.92
		SD	18.13	18.34	.99
		range	75-186	9-90	96-100
11	baseline	mean	163.08	41.44	97.26
		SD	22.10	16.38	2.44
		range	101-204	17-86	87-100
	tape	mean	161.62	38.66	96.99
		SD	20.66	15.23	2.95
		range	100-202	12-92	89-100
		mean	165.95	40.53	97.32
	post tape	SD	21.76	14.57	2.75
		range	111-201	14-106	90-100

Table 4 continued.

Subject	Segment		Heart rate	Respiratory rate	%O_2 Saturation
12	baseline	mean	120.86	33.17	98.34
		SD	13.15	16.21	1.42
		range	94-170	11-104	91-100
	tape	mean	122.77	30.63	98.17
		SD	12.43	14.62	1.53
		range	92-157	10-81	92-100
	post tape	mean	121.75	34.62	98.07
		SD	13.00	16.89	1.45
		range	97-155	10-88	92-100
13	baseline	mean	127.56	34.50	98.03
		SD	9.48	12.80	1.73
		range	100-163	12-96	92-100
	tape	mean	125.32	32.33	97.96
		SD	9.23	13.00	1.73
		range	93-151	12-81	92-100
	post tape	mean	124.40	35.21	97.76
		SD	7.81	12.96	1.84
		range	109-166	12-82	90-100
14	baseline	mean	149.31	37.02	96.56
		SD	17.50	15.16	2.06
		range	101-198	12-85	90-100
	tape	mean	147.20	37.03	96.15
		SD	17.98	15.61	2.38
		range	102-225	11-96	91-100
	post tape	mean	146.08	37.64	96.01
		SD	19.31	15.54	2.75
		range	62-189	10-83	90-100

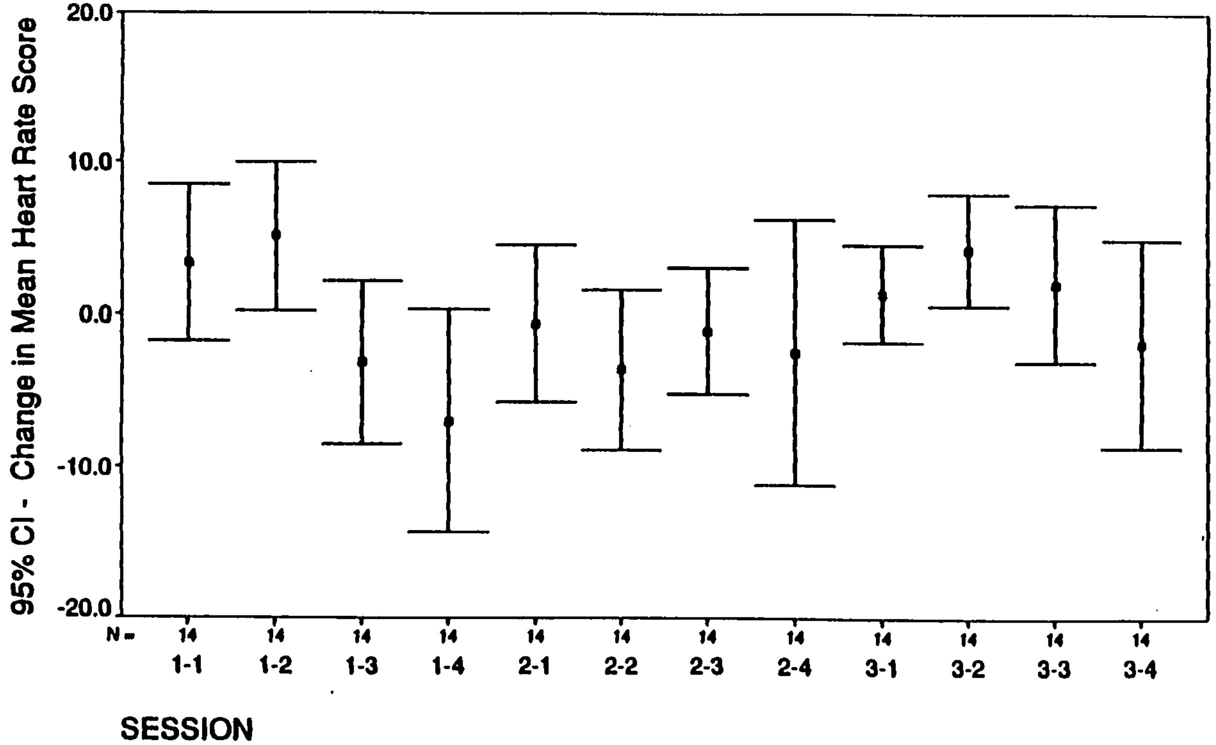


Figure 1. Mean Change Scores for Heart Rate Over Time (n=14).

(1,1-4=Day 1, Sessions 1-4; 2, 1-4=Day 2, Sessions 1-4; 3, 1-4=Day, Sessions 1-4.

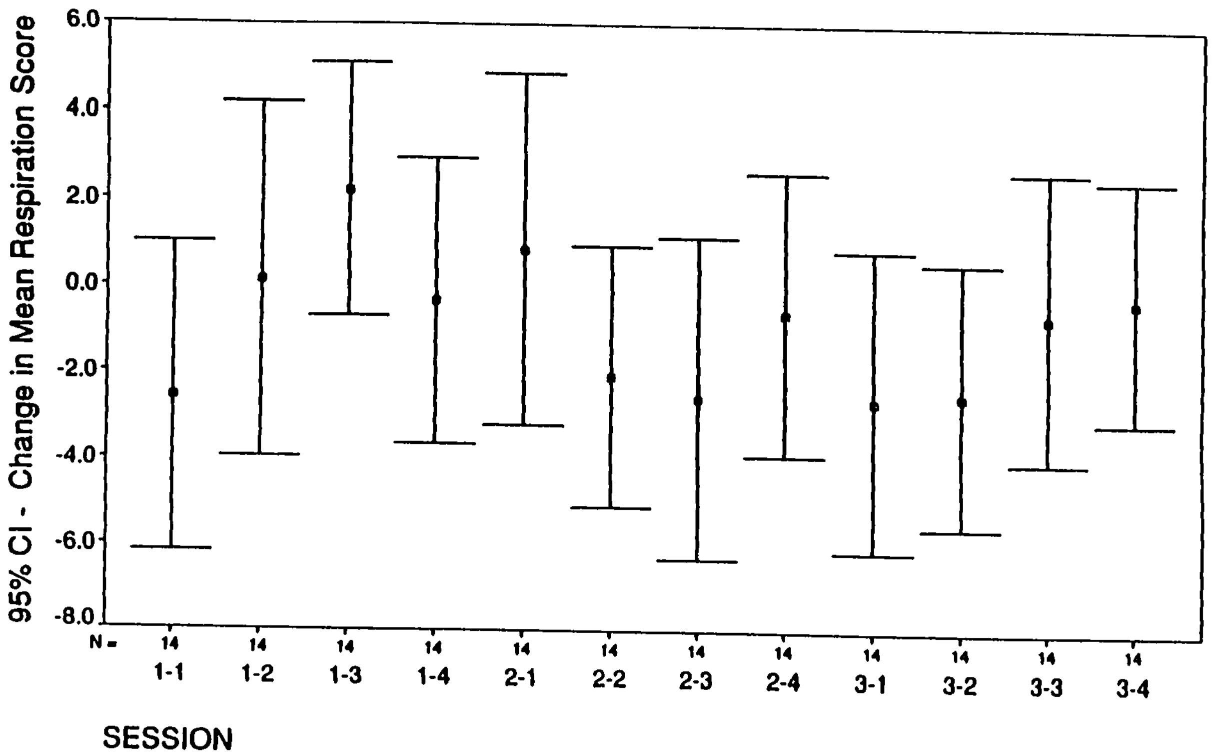


Figure 2. Mean Change Scores for Respiratory Rate Over Time (n=14).

(1, 1-4=Day 1, Sessions 1-4; 2, 1-4=Day 2, Sessions 1-4; 3, 1-4=Day 3, Sessions 1-4).

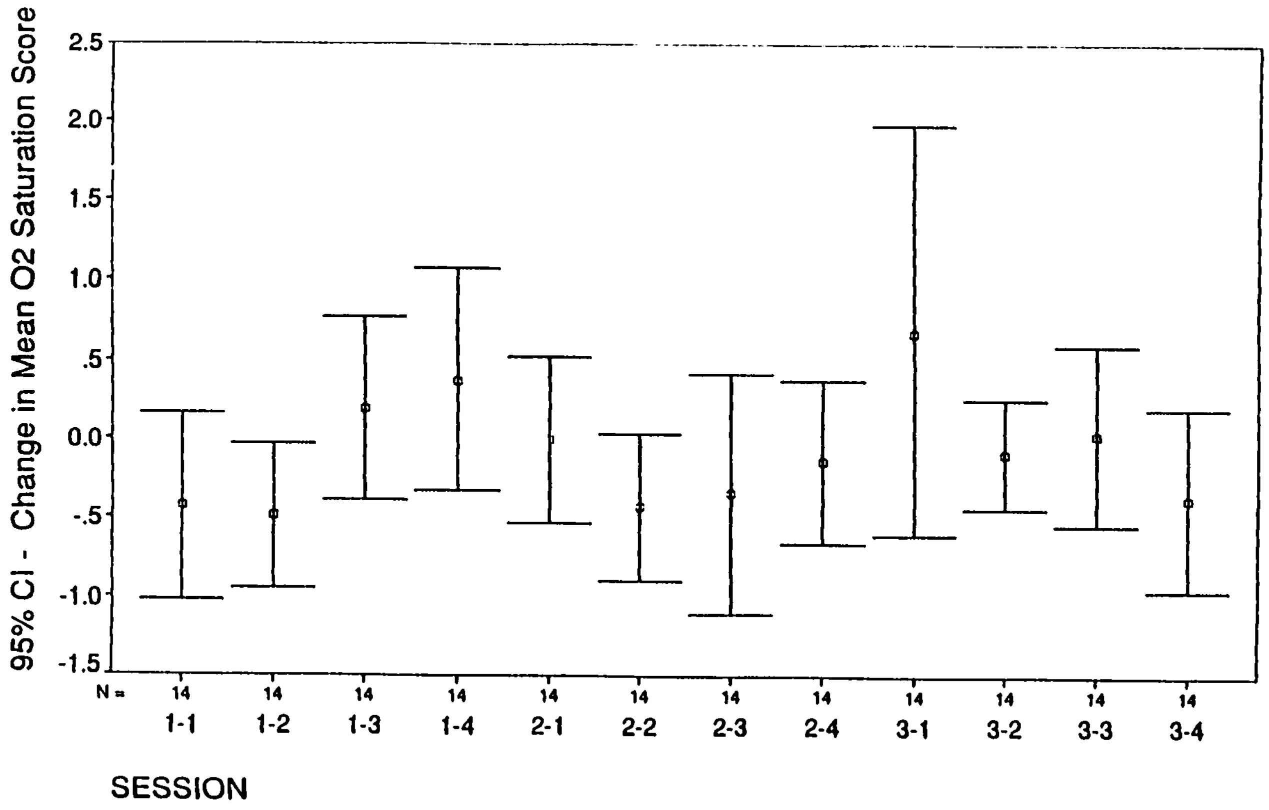


Figure 3. Mean Change Scores for Oxygen Saturation Over Time (n=14).

(1, 1-4=Day 1, Sessions 1-4; 2, 1-4=Day 2, Sessions 1-4; 3, 1-4=Day 3, Sessions 1-4).

Table 6. Differences From Tape to Post Tape Segments for All Sessions (n=14)

Variable	Tape mean	SD	Post tape mean	SD	*t*	*p*
heart rate	141.53	10.87	140.97	11.84	-.83	ns
resp rate	34.54	4.15	35.74	3.73	2.41	.03
% O_2 sat	97.56	1.44	97.54	1.35	-.15	ns
activity	2.44	.55	2.46	.65	-.22	ns
% awake	75.30	13.35	66.71	17.76	-3.09	.009
% asleep	18.13	12.85	26.19	18.30	3.95	.002
stress	.34	.19	.36	.18	.98	ns
stability	.51	.19	.45	.20	-2.14	.05
attend	.16	.11	.05	.06	-4.86	.001

Table 5. Differences From Baseline to Tape Segments for All Sessions (n=14)

Variable	Baseline mean	SD	Tape mean	SD	*t*	*p*
heart rate	141.83	11.03	141.54	10.77	.57	ns
resp rate	35.46	4.35	34.54	4.15	-1.8	ns*
% O_2 sat	97.65	1.27	97.66	1.44	1.07	ns
activity	2.50	.58	2.44	.56	.89	ns
% awake	72.22	15.10	75.31	13.36	-1.40	ns
% asleep	22.23	15.84	18.13	12.85	-1.87	ns*
stress	.34	.20	.34	.19	.21	ns
stability	.51	.19	.52	.19	.15	ns
attend	.03	.04	.16	.11	5.64	.001

*trend toward significance p= .09

Table 7. Differences From Baseline to Post Tape Segments for All Sessions (n=14)

variable	baseline mean	SD	post tape mean	SD	*t*	*p*
heart rate	141.83	11.03	140.98	11.83	-.74	ns
resp rate	35.46	4.35	35.74	3.73	.58	ns
$\%O_2$ sat	97.67	1.27	97.54	1.35	-1.35	ns
activity	2.51	.58	2.46	.65	-.66	ns
awake	72.22	14.98	66.70	17.98	1.44	ns
asleep	22.29	15.84	26.19	18.30	1.06	ns
stress	.34	.19	.36	.18	.43	ns
stability	.51	.19	.45	.20	2.18	.05
attend	.03	.03	.05	.06	2.16	.05

only subject three had a mean heart rate that was significantly different from baseline measures to exposure to the taped maternal voice using a 95% confidence interval .

Student's t- tests were performed on the infants to compare responses between study conditions. When the change in heart rate was compared from baseline to the tape segment, the tape to post tape segment and the baseline to post tape segment, no significant differences were found. These values are listed by study condition in Tables 5-7.

To determine an orienting response to the voice, heart rate was examined for an immediate change when the tape recorder was turned on. The last thirty seconds prior to the onset of the tape was compared to the first 30 seconds of the onset of the taped maternal voice. There was no significant change in heart rate during this period of time. The mean heart rates for this sample are graphically represented using a 95% confidence interval in Figure 4.

Respiratory rate

The rate of respiration of the infants for the entire sample ranged from 4 to 106 breaths per minute with an overall mean of 35.23 (SD =15.39). The change in the rate of respiration in this sample of infants from baseline measures to the tape (t= .1.07, SD =-.86, p = .09) approached significance. There was a significant increase in respiratory rate from the tape to post tape segment (t =-2.41, SD =1.8, p = .03). The baseline to the post tape segment however, failed to show significant differences. These results are listed in tables 5-7. Only Subject 12 had a change in respiratory rate during the tape

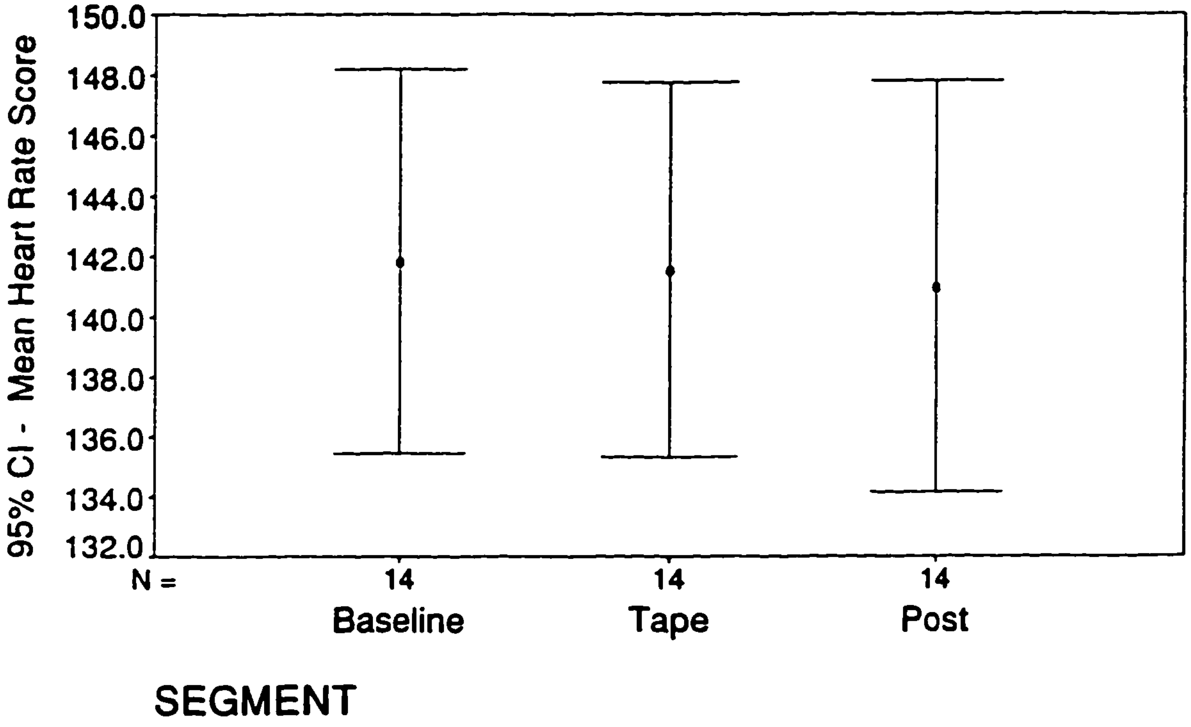


Figure 4. Mean Heart Rate for All Subjects by Segment

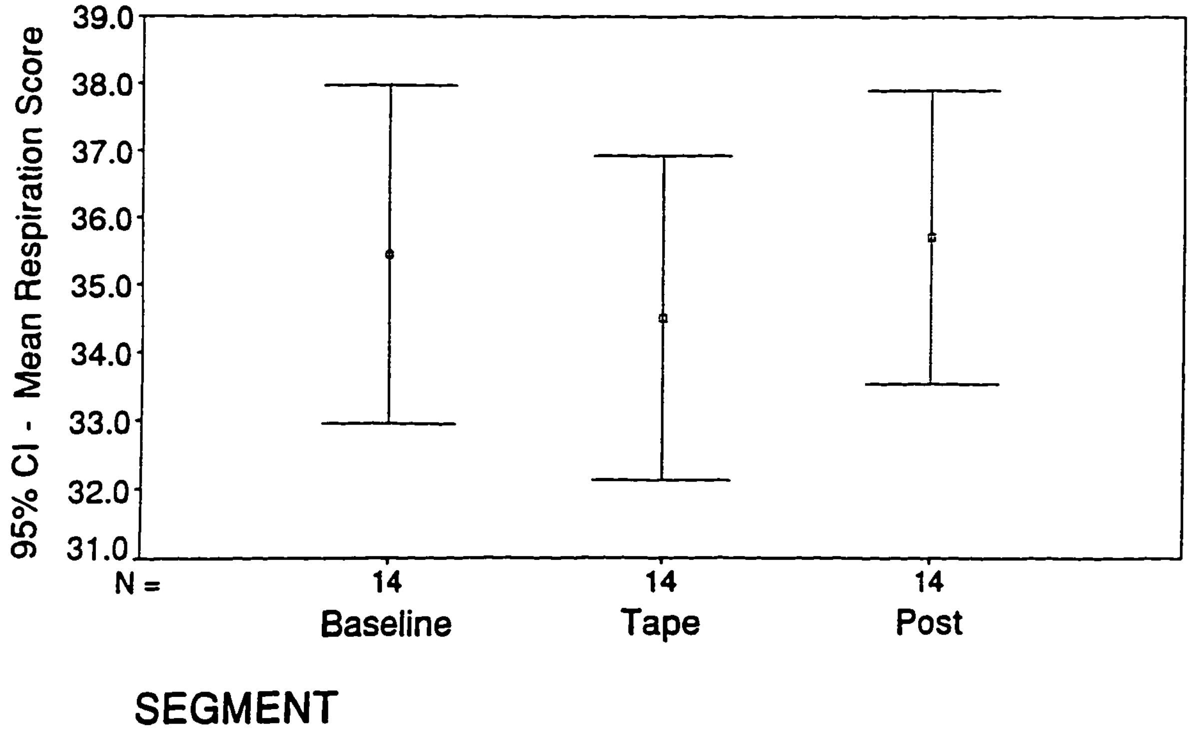


Figure 5. Mean Respiratory Rate for All Subjects by Segment

that was significantly different from zero. The mean respiratory rates for this sample are depicted in Figure 5.

Oxygen saturation

The range of oxygen saturation levels of the 14 study infants was 87-100 %. The mean oxygen saturation level for the entire sample was 97.59 (SD = 2. 36). The mean saturation levels for each infant across the 12 sessions are listed by segment in Table 4. Student t-tests comparing the baseline to the tape segments, the tape to the post tape segments and the baseline to the post tape segments were not significantly different for oxygen saturation levels. These values are shown in Tables 5-7. The mean oxygen saturation levels for the three segments are graphically displayed in Figure 6.

Behavioral Variables

The behaviors of the infants were clustered into groups for the purpose of analysis. The six infant states were reduced to three categories.: awake, asleep and crying. The definitions of the behavioral cues are listed in Appendix B. Negative behavior cues including gape face, grimace, gag, airplane, spiting up, fuss, sitting on air, arch, jerk, burp, hiccup, yawn, avert gaze were grouped into the variable stress. Stable behavior cues (smile , hands on face, frown, hand clasp, foot clasp, holding on, sigh ooh face, open face eyebrow raise, leg brace, flexion, grasping and mouthing were grouped into the variable stability. These categories for designating stress and stability in premature infants have been identified and utilized by other researchers (Lund, 1990). Attending behaviors were grouped into a variable called attend based on the attentive behaviors of the NIDCAP tool. These behaviors

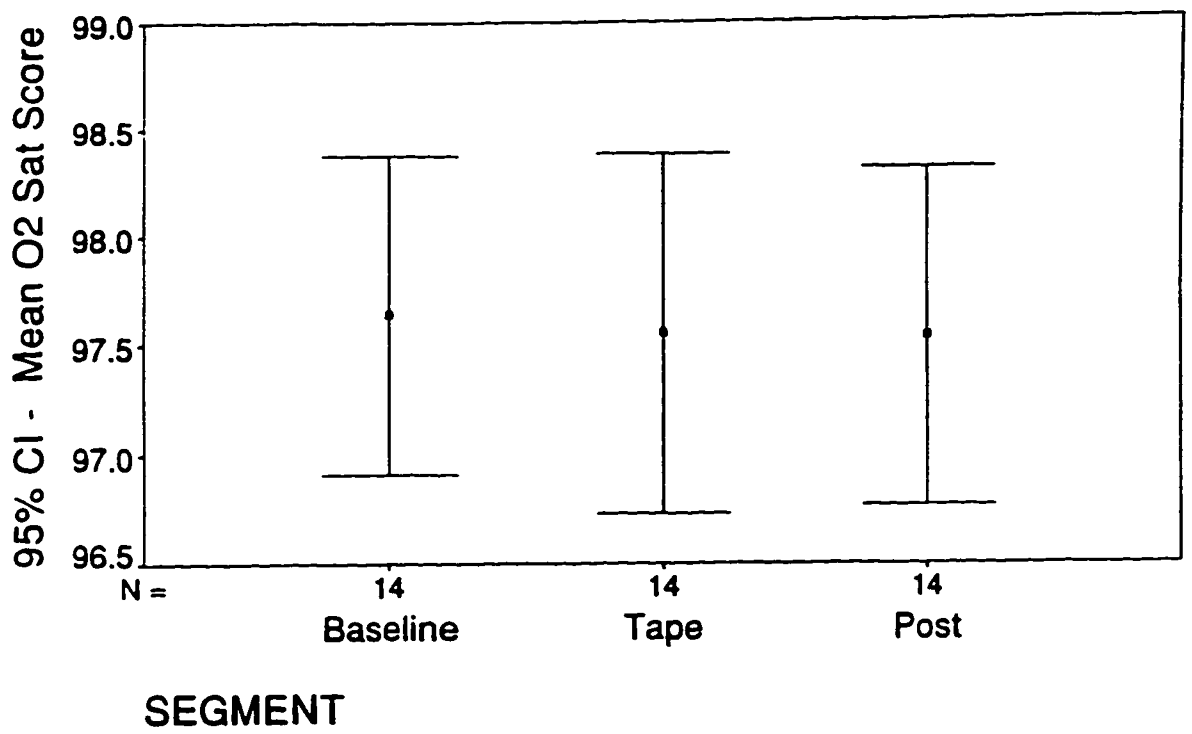


Figure 6. Mean Oxygen Saturation for All Subjects by Segment

included eyes wide, eyes brightening, grasping at ear, eyes toward source, head turn, locking, and stilling (Als, 1986).

The behaviors were quantified according to presence and frequency of occurrence. The behavioral variables were analyzed by determining and comparing differences scores across the three study conditions. Figures 7-10 graphically represent the 95 % confidence interval for the mean change scores over the 12 sessions for all infants.

The Blackburn Activity Scale is a categorical scale with ascending levels of infant activity. The mean activity level for the study infants was 2.47 (SD = 1.05). There was no significant change in level of activity between segments. These values are listed in Tables 5-7. Figure 11 displays the mean activity levels for all of the study infants.

Stress

The overall level of distress in this sample was minimal. Infant 1 was the only infant who had large enough change from baseline to tape to be significantly different from zero. Infant 10 was the only infant whose mean level of distress was significantly different from zero during the post tape segment when compared to the baseline and the taped segments. When the amount of stress was examined with the student's t test, there were no significant differences between the baseline and tape segments , the tape and post tape segment, or the baseline and post tape segments (Tables 5-7). The distribution of mean stress scores is represented by Figure 12. In addition to the stress scale, the infants were examined for the percentage of time heart

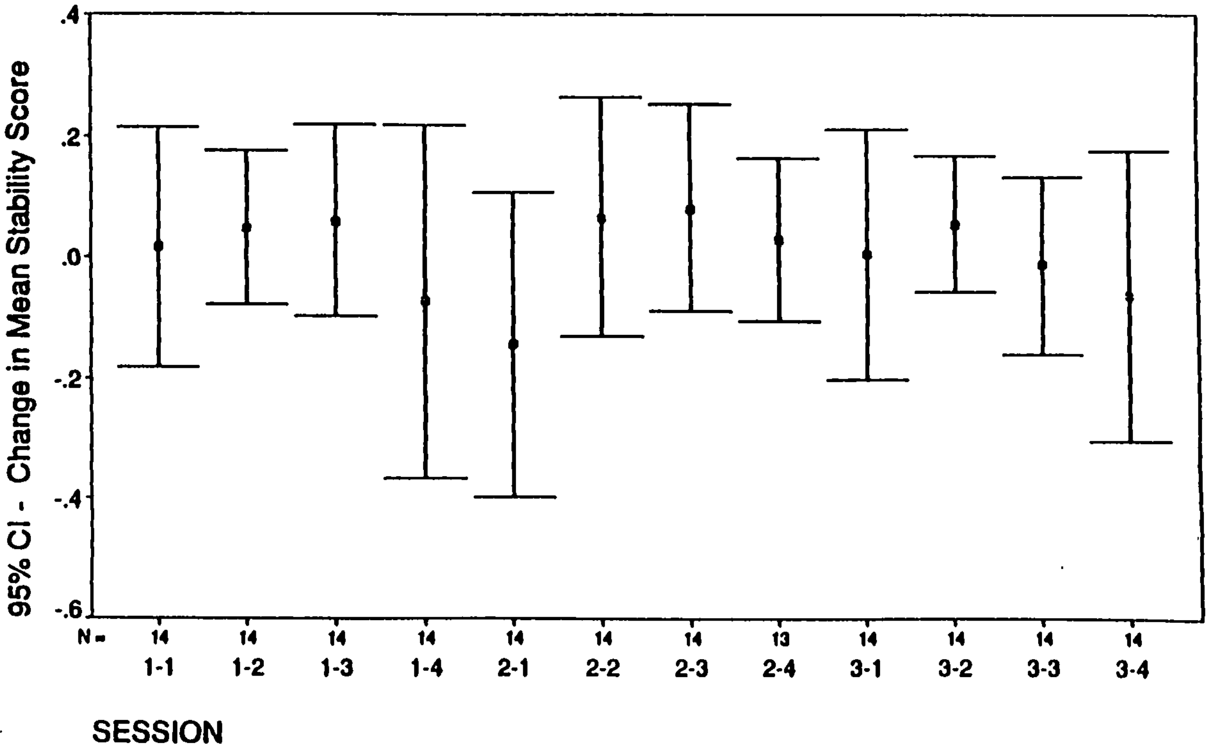


Figure 7. Mean Change Scores for Stability Over Time (n=14).

(1, 1-4=Day 1, Sessions 1-4; 2, 1-4=Day 2, Sessions 1-4; 3, 1-4=Day 3, Sessions 1-4).

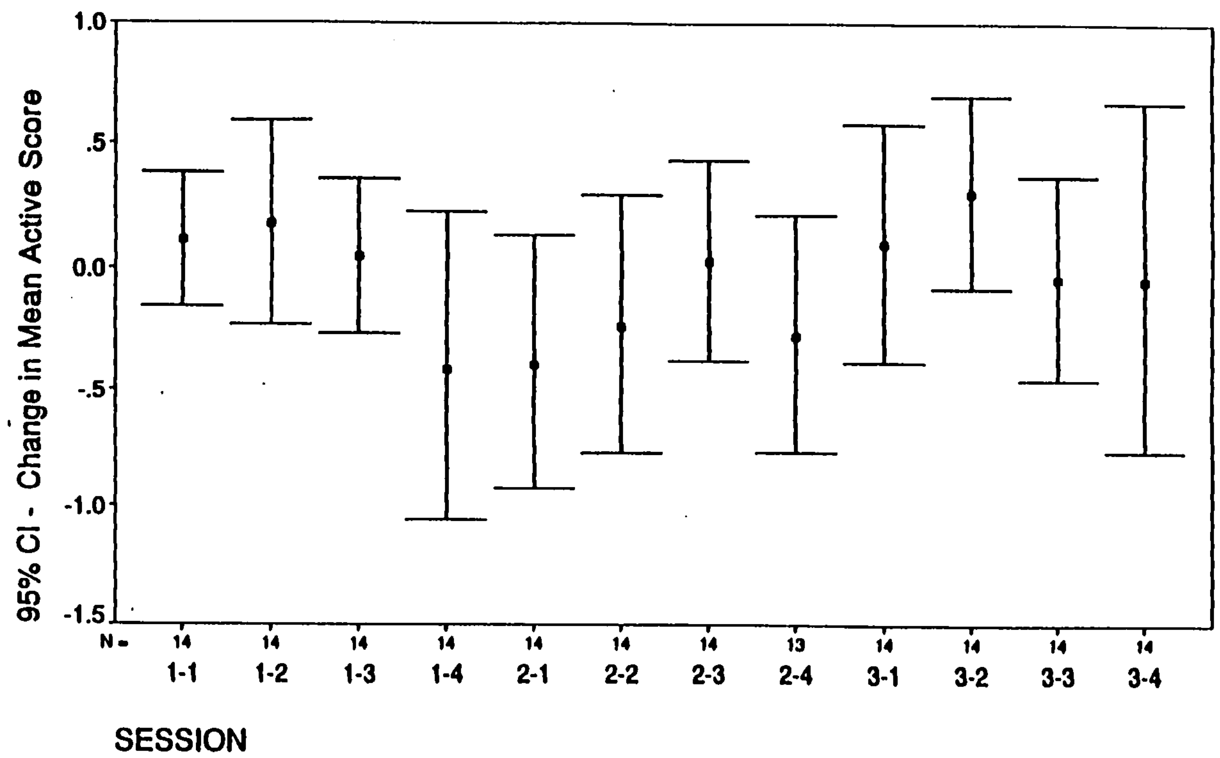


Figure 8. Mean Change Scores for Activity Over Time (n=14).

(1, 1-4=Day 1, Sessions 1-4; 2, 1-4=Day 2, Sessions 1-4; 3, 1-4=Day 3, Sessions 1-4).

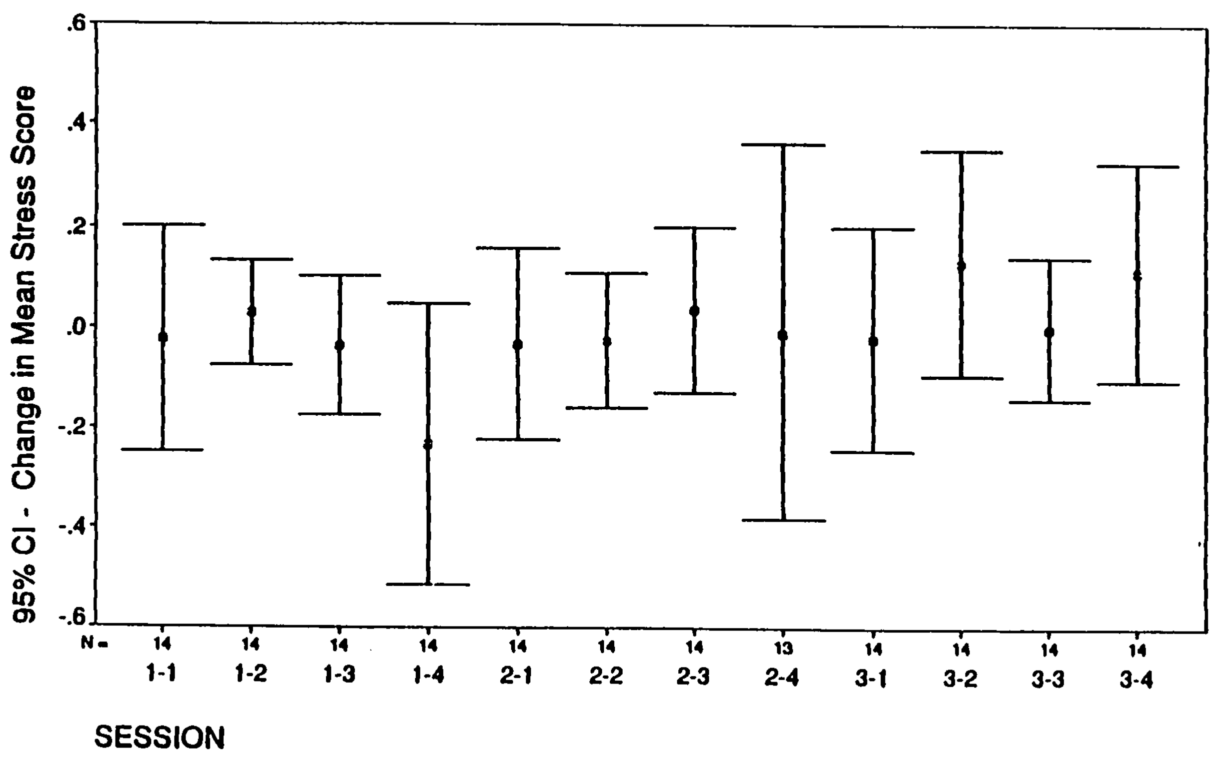


Figure 9. Mean Change Scores for Stress Over Time (n=14).

(1, 1-4=Day 1, Sessions 1-4; 2, 1-4=Day 2, Sessions 1-4, 3, 1-4=Day 3, Sessions 1-4).

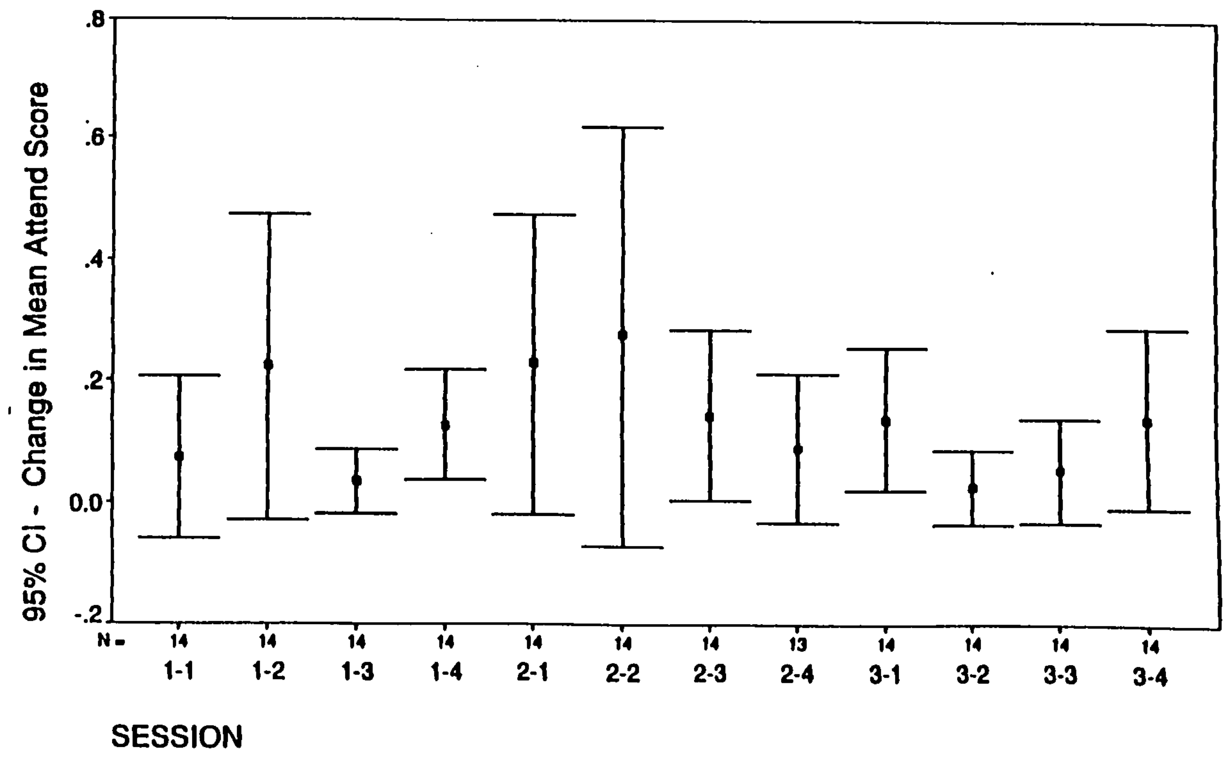


Figure 10. Mean Change Scores for Attend Over Time (n=14).

(1, 1-4=Day 1, Sessions 1-4; 2, 1-4=Day 2, Sessions 1-4; 3, 1-4=Day 3, Sessions 1-4).

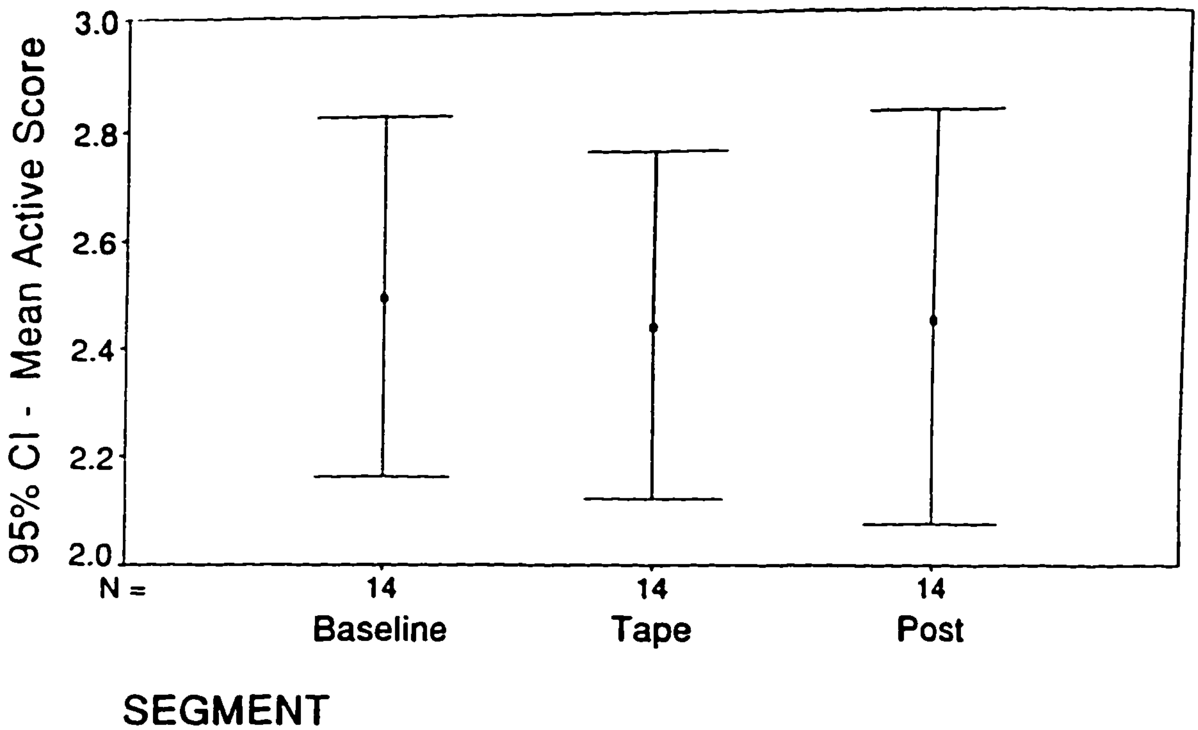


Figure 11. Mean Activity Score for All Subjects by Segment

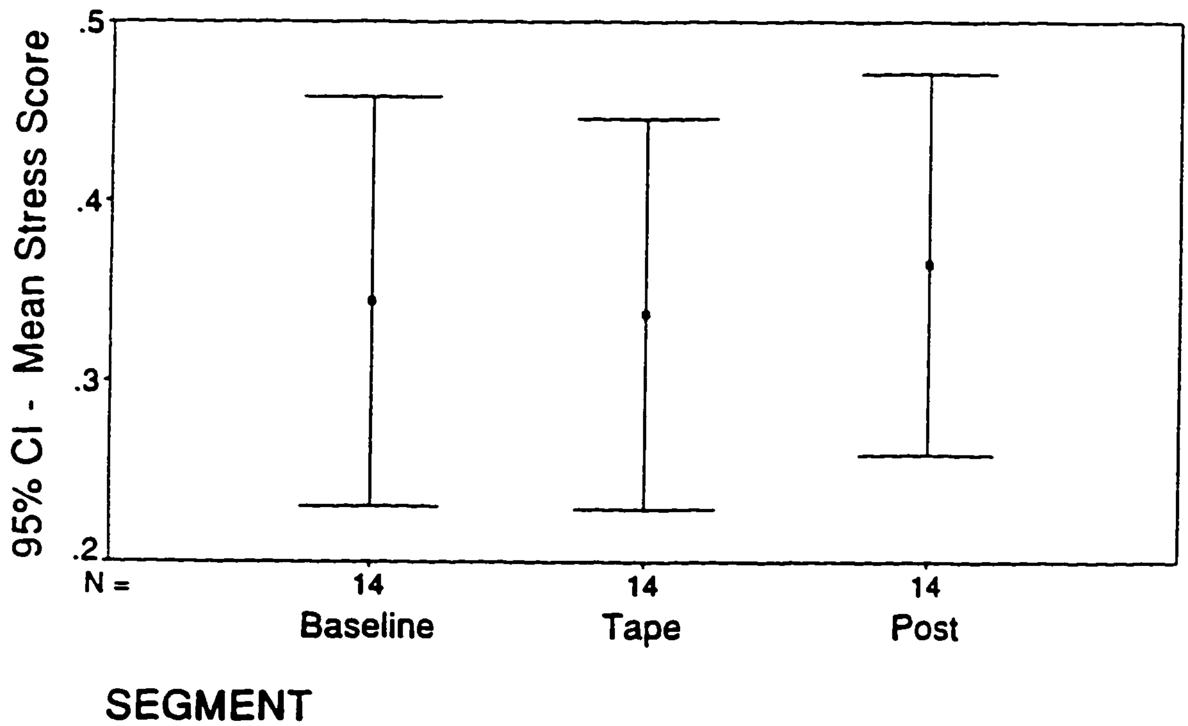


Figure 12. Mean Stress Score for All Subjects by Segment

rate was below 90 beats per minute, oxygen saturation levels were below 90% and activity levels were greater than 5 for more than 20% of the time. There was no evidence of significant distress in this sample of infants.

State

The infant states were collapsed into the categories of awake, asleep and cry for the purposes of analysis. The infants were awake 71.4% of the time. Only 5% of the time was spent crying. Study subject 1 was the only infant whose amount of crying from baseline to tape was significantly different from zero. The percentage of time awake only differed from zero for baby 5.

Neither of the comparisons with student's t tests was significantly different for infant states from the baseline to the tape segments or from baseline to post tape segments (Tables 5 & 6). However, significantly more infants were asleep during the post tape segments when compared to the taped segments ($t = 3.95$, $p = .002$, Table 7). The distribution of infant states for the sample is depicted in Figure 13.

Stability

During the tape, infants 10 and 12 had relaxed scores that were significantly different from zero. The difference however was not significant for the whole sample. The t-tests comparing the tape to the post segment for all infants was significant ($t=-2.14$, $P =.05$). From the baseline to the post tape segment, 9 of the 14 infants showed a decrease in relaxed behaviors. This difference was also significant ($t=2.18$, $p = .05$). These comparisons are listed in Tables 5-7. The mean stability scores are graphically represented in Figure 14.

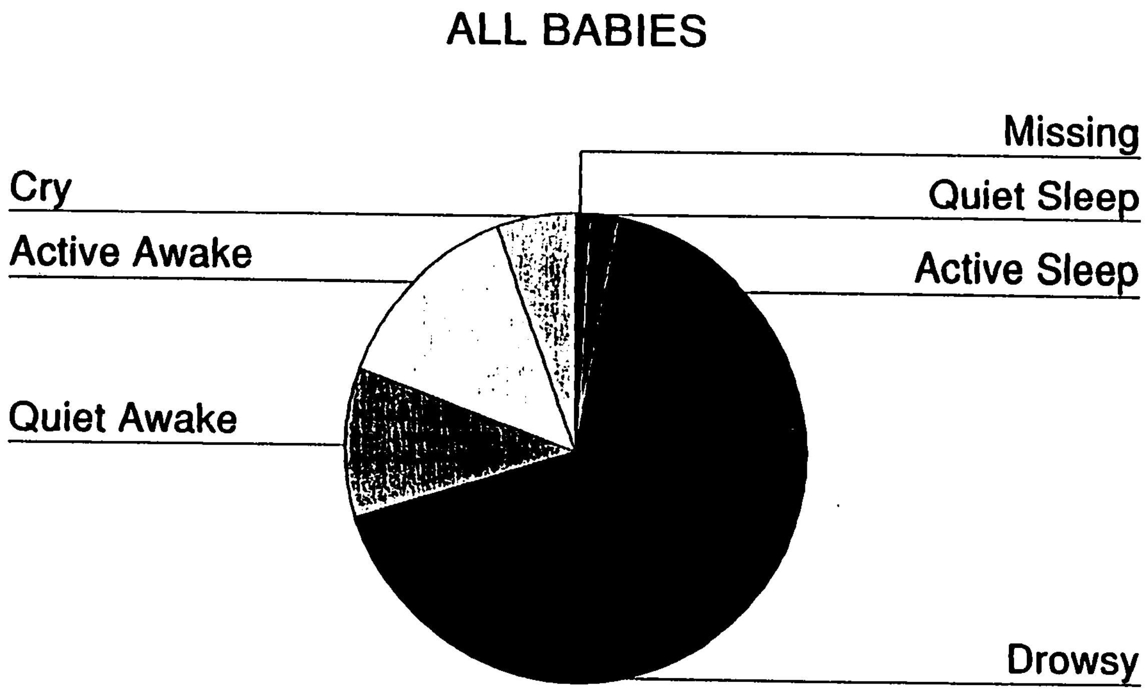


Figure 13. Sample Distribution of Infant States Over All Sessions (n=14).

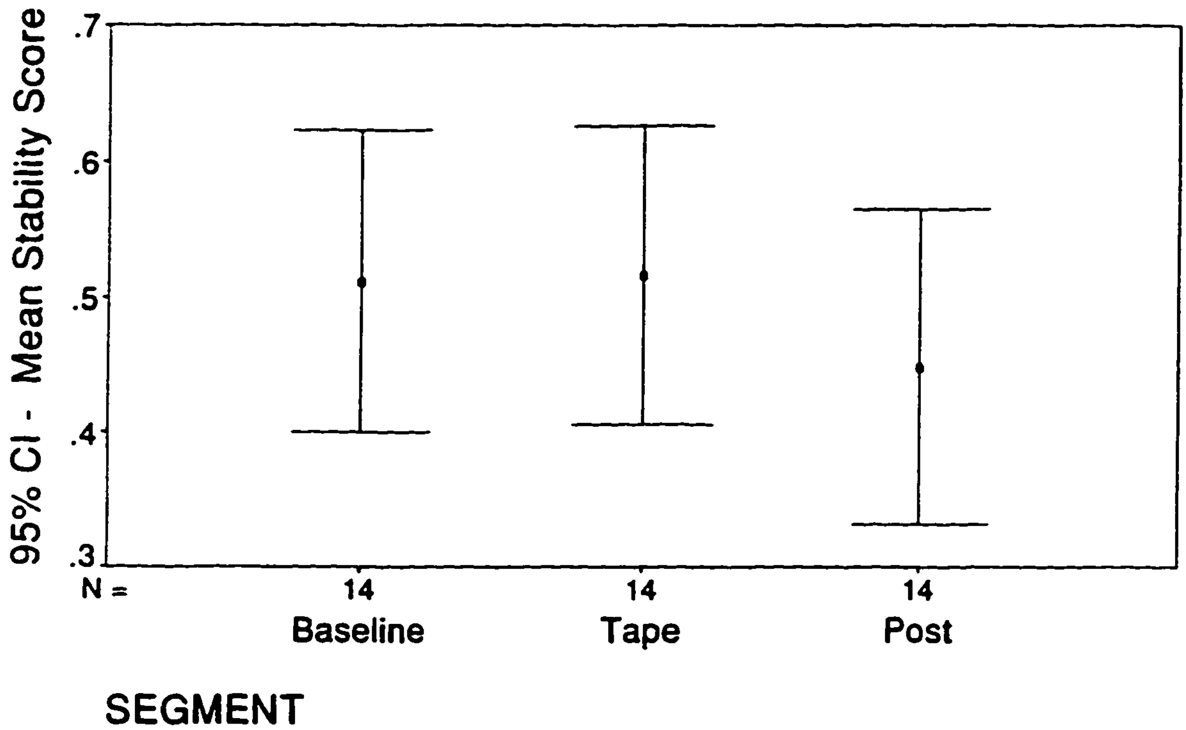


Figure 14. Mean Stability Scores for All Subjects by Segment

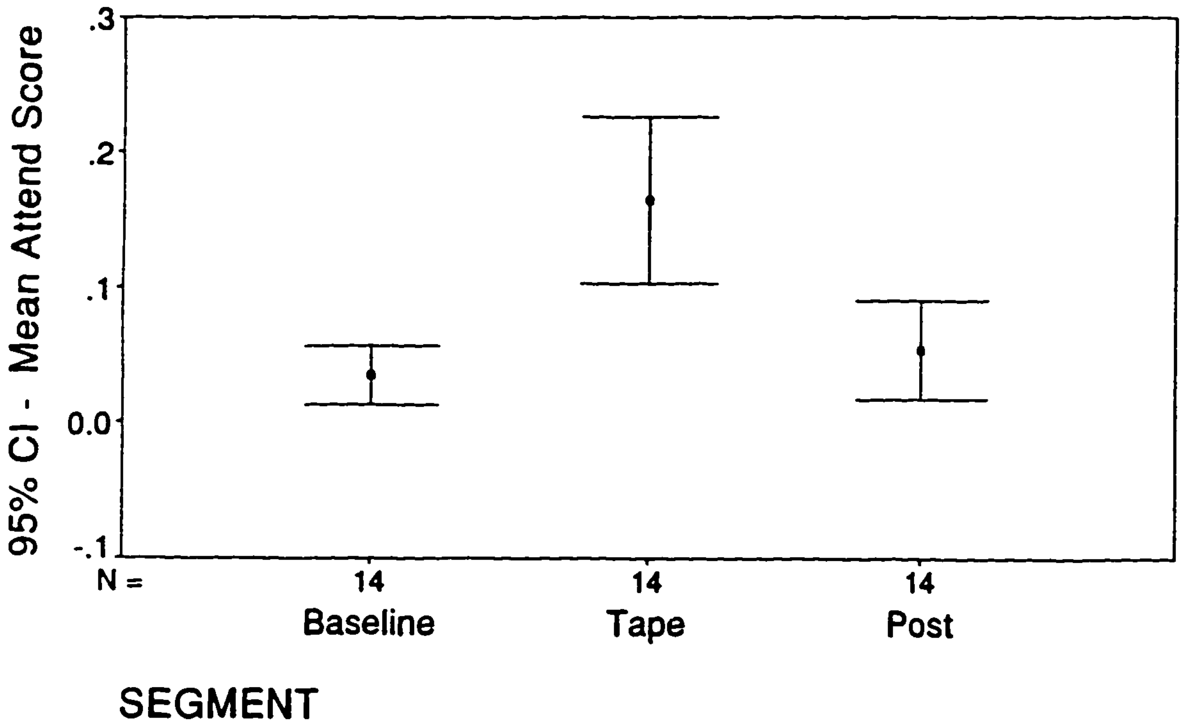


Figure 15. Mean Attend Score for All Subjects by Segment

Attend

Although attending behaviors were not observed in all sessions, all of the infants had positive change scores for the attend scale. T tests performed under each of the study conditions all revealed significant differences. (Tables 5-7). The difference was significant from baseline to tape segment ($t = 5.64$, $p = .001$), from the tape segment the post tape segment ($t = -4.86$, $p = .001$) and from the baseline to the post segment ($t = 2.16$, $P = .05$) . These values are depicted in Tables 5-7. Graphic representation of the mean attend scores are depicted in Figure 15.

Pattern Analysis

A visual inspection of the individual infant patterns was performed. The data were observed for similarities and differences across sessions for each infant over the three day study period. Infant patterns were also compared for commonalties among infants.

Each of the infants physiologic and behavioral scores were plotted in 10 second intervals across the three segments. The plots of the 12 sessions for each infant is located Appendix G. Each plot displays a specific variable along with the pattern of infant state during that session. The curves are generatated by fitting a robust nonparametric nonlinear regression function to the variable means (the Lowess algorithm) (Cleveland, 1979).

The infants were highly variable in their responses. The patterns of responses differed for most of the sessions. In addition to varying from one another, each infant's data over the three day period were highly variable.

The patterns for each of the physiologic and behavioral variables for the infants across sessions were qualitatively compared for similarities.

Although there were fluctuations, there were a few identifiable patterns for each of the study variables.

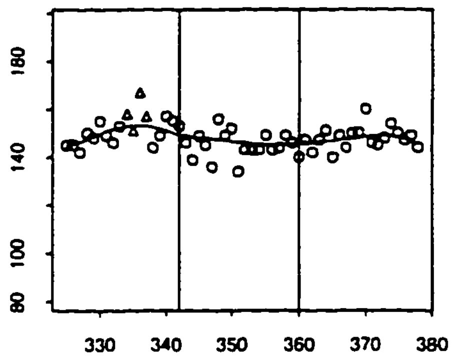
The mean heart rates for all 12 infants were somewhat lower from session 1 to session 4 or the first and last sessions of each study day. However, on both day two and three, the pattern at the first session did not resemble the last session of the day before. Therefore, there did not seem to be a carryover effect or a progressive trend over the three day study period.

Although there was are large amount of variability both among sessions for each infants and between the study infants, there were some similarities in the pattern of responses over the three days. Upon visual inspection, the recurring patterns were identified. The following plots are examples of similar patterns seen across the study infants for the behavioral and physiologic variables.

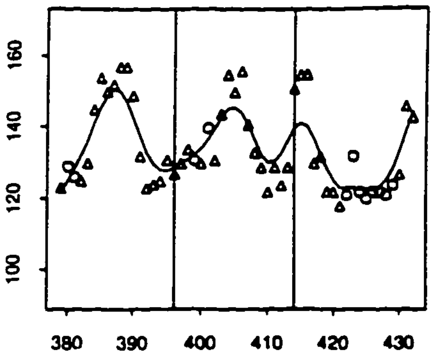
<u>Heart rate</u>

Three general patterns of heart were seen across multiple babies. These patterns were:

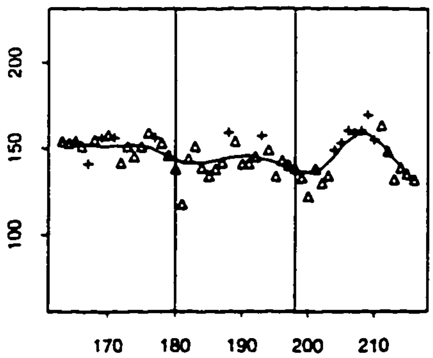
1. Heart rate was fairly flat with a small decrease during the tape.



2. A heart rate pattern that was constantly changing.



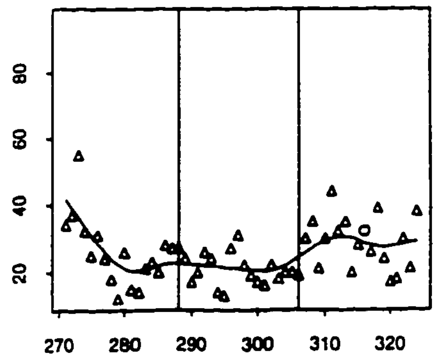
3. An increased heart rate during the post tape segment.



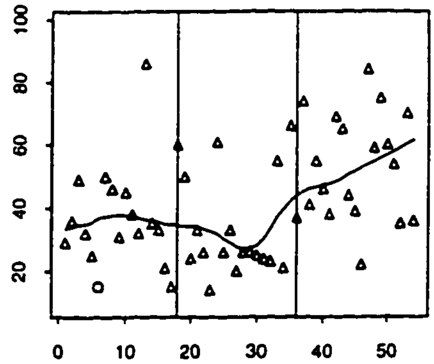
Respiratory rate

Although respiratory rate patterns also varied, there were two recurring pattern for respiratory rate that were frequently seen:

1. Respiratory rate was fairly uniform with a slight decrease during the tape.

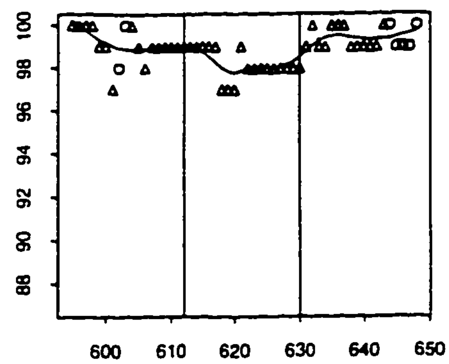


2. Respiratory rate sometimes increased during the post tape segment which is depicted below.

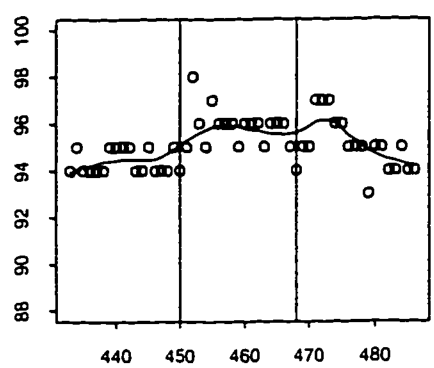


Oxygen saturation

The pattern for oxygen saturation readings sometimes seen was a slight decrease during the tape segment:



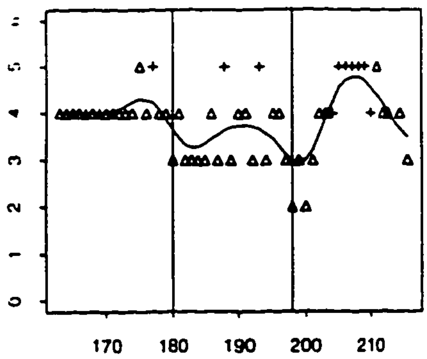
Large fluctuations in oxygen saturation were not seen although the levels sometimes increased during the tape and then decreased slightly during the post tape segment.



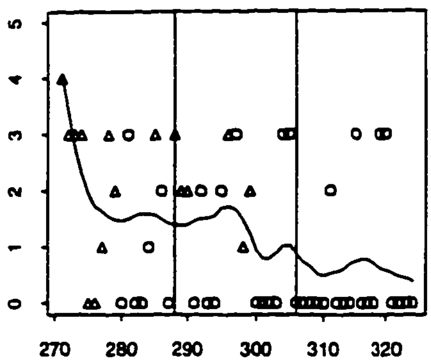
Activity

Two predominant activity patterns were recurring within the sample.

1. The level of activity was generally lower during the tape segment and increased in the post segment.

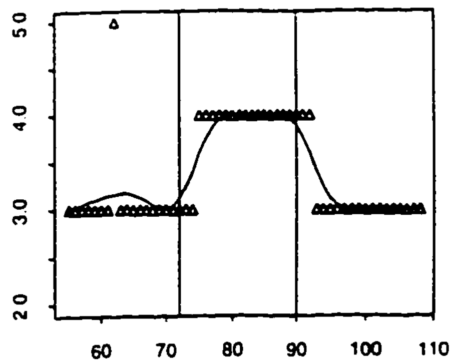


2. There was a decline in movement across the segments.

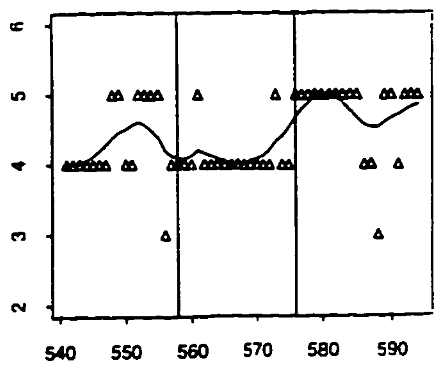


Infant state

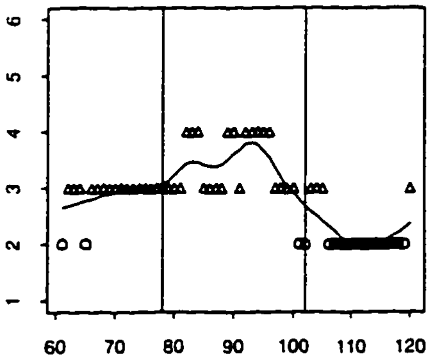
Infant states fluctuated throughout the sessions although the infants were sometimes in a quiet awake state during the tape segment as depicted below.



In some of the infants, their level of arousal increased during the post tape segment.



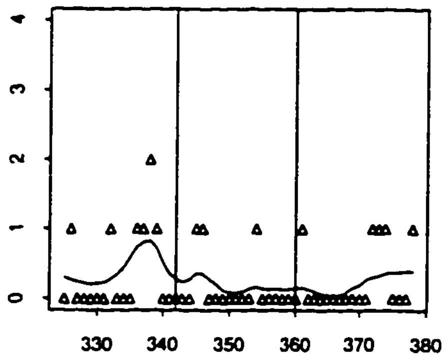
A third recurring pattern was for the infants to become more sleepy during the post tape segment.



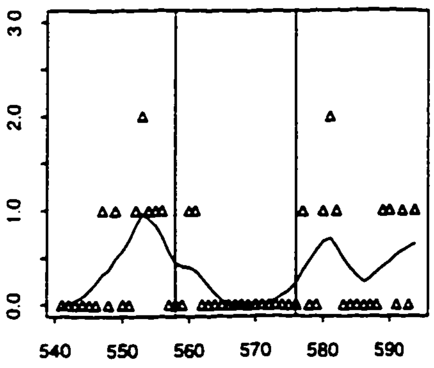
Stress

The level of stress displayed in all the plots was very small. There are two patterns that were found to reoccur in this sample.

1. The stress behaviors decreased from the baseline.

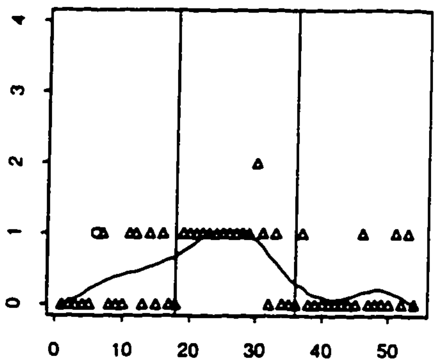


2. Some infants had less stress behaviors during the tape than either the baseline or post segments.



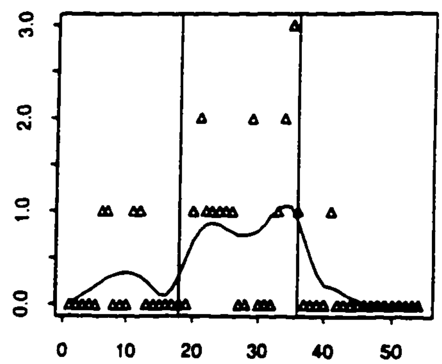
<u>Stability</u>

The stability cues of the infants often increased during the tape segment and returned to the baseline pattern.



Attend

The pattern for attending was similar in all of the plots for those infants who displayed attending behaviors and is depicted below.



Although the infant responses were highly variable throughout the study, when the infants patterns were examined over the 12 sessions, the infants trended toward less activity, more stable behaviors, lower respiratory rates, and lower heart rates during the tape segment. These trends are displayed graphically in Figures 16-98 in Appendix G. However, it was difficult to detect a change statistically due to the high variability in this sample.

Summary of Findings

The results of this study suggest that premature infants are capable of attending to intermittent exposure to taped maternal voice without undue stress. There were no significant differences in heart rate, or oxygen saturation throughout the study conditions. There was a trend toward significance in lower respiratory rates from the baseline to the tape segment.

There was a significant increase in respiratory rate during the post tape segment when compared to the tape segment.

From the baseline to the tape segment, the infants showed significantly higher amounts of attending. Stability behaviors were significantly higher during the tape segment as well as attending behaviors when compared to the post tape segment. From baseline to the post tape segment, the infants were more likely to be asleep, but continued to show more attending behaviors if awake. There were significantly less stability behaviors from baseline to post segment. The infants trended toward less activity during the taped segment and more wakefulness. The level of stress was minimal across all study conditions.

CHAPTER V Discussion

The results of this study indicate that premature infants are responsive to maternal voice stimulation and display attending behaviors when exposed to taped maternal voice. This finding is consistent with another comparable study where premature infants were shown to have longer periods of eye opening when talked to by an adult female (Eckerman, Oehler, Medvin, & Hannan, 1994). Talking to infants has been reported to have the greatest impact on developmental outcomes when early assessments are compared to later cognitive tests (Cohen, 1995). It has also been documented that responsiveness to auditory stimulation correlates with intellectual performance at 8 years (Wallace, Rose, McCarton, Kurtzberg, & Vaughan, 1995).

Research Aim 1

The first aim of this study was to describe the behavioral and physiologic responses of premature infants to taped maternal voice. The baseline behaviors of the infant were consistent with what is usually observed. There were varying amounts of random movement. The study infants tended toward less activity and more stability cues during exposure to maternal voice. Stress cues were sometimes present but did not increase during the tape segments. The infants demonstrated significantly more attending behaviors during the tape segment indicating the ability to alert and attend to maternal voice.

The physiologic variable in this study stayed fairly static throughout each of the three study conditions. Although there was a large range in heart rate and respiratory rate, this was consistent over all study conditions. The study was unable to distinguish an orienting response. The period of time chosen to examine this aspect was 30 seconds after the onset of the tape. This may have been too brief, due to the latency of premature infant responses, or may have been too subtle to detect. There was minimal stress in this sample of infants overall. There was no observable increase in behavioral distress with the exposure to maternal voice. Other factors that may have indicated stress such as bradycardia, high levels of body activity , and oxygen saturation levels below 90% were also examined. There was no evidence of significant physiologic stress in this sample of infants. Exposure to taped maternal voice in a controlled situation such as this study appears to be a safe intervention for premature infants.

Research Aim 2

The second research aim was to determine the behavioral and physiologic responses of premature infants to repeated exposure to taped maternal voice. In any group of premature infants it is difficult to elicit a response, and a single measurement would not have been useful. Repeated measures provide not only more opportunity to determine effect of a stimulus, but also validation of the effect when seen more than once (Barlow & Hersen, 1994). It was also thought that there may be an increase in responsiveness over the three study days. A significant effect over time was not found. The responses of these infants were highly variable without a definite discernible pattern over the three days of exposure. There are several possible reasons for the results. Premature infants are a highly heterogeneous group with notable individual differences. As in any clinical environment, the environmental conditions were dynamic and frequently changing. This sample, although considered to be healthy, since none of the infants had significant respiratory distress at birth, displayed irregular breathing patterns and wide ranges in heart rate. This large amount of variability resulted in inconsistent patterns for all infants.

It is probable that at this early stage of development infants may be unable to store information from one experience to another. It is also possible that the three days of exposure to maternal voice was too short a period of time to measure evidence of learning. A recent study by Thoman (1993) utilized a breathing bear for several weeks during hospitalization of premature infants. Infants in that study actively sought contact with the breathing bear demonstrating that premature infants are capable of instrumental learning. In the current study however, it was not possible to determine a learning effect over time.

<u>Research Aim 3</u>

Quiet wakefulness is reported to occur in with premature infants only about 7% of time (Holditch Davis & Thoman, 1987). In general, when premature infants at term have been compared to fullterm newborns they show greater period of alertness, longer nonalert waking activity and more sleep-wake transitions. These differences are believed to be a function of the developing central nervous system as well as a reflection of chronological age or the extended period of time in the extrauterine environment. Context-related state differences have been found. Premature infants fuss and cry more when alone and tend to be awake longer when their mothers are present (Holditch Davis & Thoman, 1987). Uneven development of infant states has been suggested in premature infants (Parmelee, 1974). Although there is a linear decrease in active sleep and increased periods of quiet sleep similar to term infants, there are differences in premature infant sleep patterns such as more movement during quiet sleep (Whitney & Thoman, 1994).

The infants in this study tended to be more awake in general (71% of the time) than what might have been expected. This may have been a reflection of timing of the intervention since many premature infants are often awake prior to feeding times. In addition, transitional wakefulness was not distinguished from quiet awake for the purpose of analysis.

Study Limitations

Timing

The infants were entered into the study before the end of the first week of life. This time period was chosen to determine infant responses at the gestational age they were born, as well as to examine their responses prior to receiving significant exposure to their mother and other types of sensory stimulation. Maturation can be a significant threat to internal validity in that children are developing new skills rapidly and the passage of time can distort the influence of the independent variable (Woods & Catanzaro, 1988).

The major disadvantage to the decision to begin data collection prior to the second week of life was that these infants were still in the process of adjusting to the extrauterine environment at the time of the study. There were multiple demands placed on the infants such as beginning to feed and maintain their body temperatures. Each day the circumstances were somewhat different for contemporaneous events. These other activities also required energy from the infants with may have limited the energy available to respond to a stimulus.

The period of time just prior to feeding as the point of data collection also presented problems. The infants were frequently getting hungry by that time and easily distracted. On the other hand, since the repeated sessions were determined by their care schedule, they may have been sleeping at the time of data collection and therefore not as responsive as they might have been.

The reason for conducting the study over the three day period was to determine if there would be an increase in attending or alert states. There are several possible reasons for why this did not occur. Premature infants may not have the capacity for memory at early gestation. The conditions for the infant seem to be different each day (e.g. adding oral feeds to their gavage regime, or increasing the volume feeds). This changed the overall conditions for the infant. There also seemed to be too much time lapsed from the last session on one day to the first session of the next for the infant to remember the stimulus. In addition, three days might not be long enough for learning to occur.

Repeated Measures

Other threats to internal validity included repeated testing of the infants. It was hypothesized that the infants may incorporate information from one session to the next and display some learning by the end of the study period. The infant responses were so variable however, that although there was some suggestion of subtle patterns occurring over each day from session 1 to session 4, each day appeared to be a novel experience with little carryover by day three.

Due to the individual differences of premature infants, a small sample study with multiple measurements is probably the best approach (Kazdin, 1982). However, the nature of prematurity did not allow for a completely stable baseline, and the large variability throughout the sessions made it difficult to detect a change.

Equipment

Whenever several pieces of technological equipment are used there is always the possibility of measurement error, artifact, and equipment breakdown. Although every effort was made to calibrate and test the equipment prior to each data collection session, technical problems with equipment occasionally occurred.

Competing Variables

The environments of the two study facilities were similar in medical management and acuity. The atmosphere generally was calm, but admissions into the nurseries would increase the overall level of activity and noise level. There were overhead fluorescent lights that were frequently turned down, but needed when other infants required intervention. The alarms from monitors and infusion pumps sounded regularly as well as noise occurring from movement of equipment and discussions of the staff and families. Facility 1 was a smaller physical space which may have had an effect on the overall noise level. Although there was generally little interference from the nurses and physicians during data collection, the infants all required exams and laboratory tests as well as other occasions for handling in the periods in between the study sessions.

Sample

All infants who met the inclusion criteria were entered into the study. The majority of the sample were Caucasian and did not provide a broad representation of different ethnic variations. However, to facilitate the participation of a Mexican infant, the study script was translated into Spanish and read by the mother in her native language.

Some infants were not included in this study due to young maternal age. Since there are may premature infants born to teenage mothers, the results of this study does not provide information concerning those infants. The sample was small and the results are not generalizable to all premature infants. It does however give some information concerning similarities of responsiveness.

There were also some individual subject differences in this sample. Subject 1 was an extremely reactive infant who seemed to be highly sensitive to any handling or stimulation and displayed few signs of self regulation. This type of infant may not be best suited for this intervention. Swaddling and minimal stimulation demands may have been warranted for this infant until he displayed signs of less reactive behavior. In this case, although there was no increased distress in this infant with the maternal voice tape, the level of responsivity was probable not representative and his true capability is not known.

Subject 13 began as a stable premature infant but then subsequently developed necrotizing enterocolitis. His behavior which was quite animated and alert upon entrance into the study, changed to more sleepy behavior and less expressiveness when awake. He however, showed less variability in responses and even appeared at times to be somewhat soothed by the maternal voice tape. This infant had less stress cues than some of the other infants indicating that even sick infants may benefit from maternal voice intervention.

Implications for Nursing Practice

Premature infants demonstrated a significant change in attending behaviors when exposed to taped maternal voice. The results of this study indicate that premature infants are responsive to voice and are capable of brief periods of alertness. Premature infants who have been studied post term have been described as less responsive, less alert, and showing less clear behavioral cues (Vohr, 1991). Ways to improve responsiveness in these infants is necessary to prepare them for future social encounters that provide opportunities for learning and growth.

The infant responses in the current study were highly variable reflecting a variety of concurrent demands placed on these infants during their stay in the hospital environment. The overall indications are that even healthy premature infants are still very immature in their level of functioning and neurorganization. Infants are expected to achieve certain skills prior to discharge to home placing additional performance demands as well as exposure to sensory input from the surrounding environment and other human beings. Periods of distraction may be related to infant exhaustion, physiologic fluctuations and these other environmental stimuli.

Interventions tailored to the developmental levels of premature infants have demonstrated improved results during hospitalization in the incidence of fewer complications, shorter periods of artificial ventilation and improved weight gain (Als, Lawhon, Duffy, McAnulty, Gibes-Grossman, & Blickman, 1994). Improvements in the behavioral responsiveness of premature infants may help them to be more emotionally and socially ready for environmental stimulation. Future improvements in outcome is believed to be strongly dependent on psychosocial intervention and the benefits that may be obtained from learning (Hack, Breslau, Aram, Weissman, Klein, & Borawski-Clark, 1992).

Conflicting results of multiple studies currently do not give a clear picture of the level of functioning of premature infants prior to term or even the extent of risk to their development. The current investigation lends some support to the early responsiveness of premature infants to an auditory stimulus. The rapid evolution of medical technology is producing different children in the 1990's after the NICU experience and longitudinal data from infants born in the 1970's may not be comparable. In addition there is a wide range of medical conditions as well as differences in both gestational and chronological ages that may be present in any one NICU. This situation requires updated research and constant awareness that there are marked individual differences in this population.

There is beginning insight into the process of early development and function of premature infants. This study provides some preliminary information on the early abilities of premature infants to respond to sound. Infant state regulation continues to be an important variable. The infants in this study were frequently either sleeping or in an active awake state. There seems to be only a brief window of time when these infants are optimally receptive. The ability to identify this clinically will help to prevent the frequent occurrence of social stimulation when infants are unable to handle it.

Recommendations for Future Research

Premature infants are difficult to study. Measurement options are limited, and research must be conducted in an interfering, restrictive environment. Abilities of premature infants are assumed to be limited due to absence of evidence otherwise. We currently do not know the optimal amount, timing, or duration for stimulation and have limited data on specific infant responses or boundaries of tolerance. We are just beginning to understand early neurobehavioral organization. There is clearly a need to explore modalities that make sense for the development of the premature infant given the constraints of the environment, other intervening biomedical issues, and salient factors related to normal processes. The ultimate goal is to prevent deficits and facilitate normal social integration.

Due to the additional energy requirements around caregiving periods as well as the physiological effects of hunger or satiation, it may advisable to consider using the midpoint between feeding as a time to test infant responses. Since this may require a disruption in sleep, it must be carefully executed. Attempting to bring the infant to an alert state prior to introducing the taped maternal voice would also increases the chances for a good response. Eckerman et al., (1994), were successful about half the time in facilitating an awake state prior to examining premature infants for responses to talking and touching.

Another consideration would be adjusting the length of the tape. It appeared that occasionally the infants were beginning to show interest about half way through the tape, which suggests that a longer period of exposure might be beneficial. To see an effect over time, it may necessary to repeat the intervention for up to week. With a longer tape recording, there would be more data points obtained and time series analysis could be utilized.

Since the premature infants in this study were concurrently in transition into the extrauterine environment, perhaps a period of time such as two weeks of age may also give a clearer picture of their capabilities. Since this study has provided some preliminary information concerning the premature infant's ability to attend, then using a later age should not be a disadvantage.

The current study should be replicated with infants who are more medically fragile and younger in gestation at birth. Since it has been demonstrated that taped maternal voice does not appear to add additional stress to stable infants, beneficial effects may also be achievable in this group.

The use of taped maternal voice may ultimately improve premature infants receptive language skills, due to more experience with human voice. The use of maternal voice as an intervention during the NICU experience has the potential to augment adverse stimuli and better prepare them for future for social interaction.

It would be advantageous to compare a group of premature infants who had not had the exposure to taped maternal voice during hospitalization, to a treatment group. The two groups could be followed up just prior to discharge for differences in interactive behavior with their mothers.

Brazelton (1980) has formulated the theoretical idea that variability and range of behavior are adaptive features for ongoing development. In essence, the shape of the recovery curve may be a better indicator of later functioning than performance at a single point in time. Important questions concerning interventions with premature infants that need to be answered include choice of stimulation, range of responsivity, appropriate gestational age for intervention, stability of measures over time and identification of trends in infant responses. This study provides some information on an important stimulus: maternal voice and the varied ranges of responsivity of premature infants.

The major premise of exposing premature infants to maternal voice was to gradually introduce them to social stimulation and to perhaps prolong their awake periods. Improving the level of responsiveness of premature infants as well as their ability for processing information is necessary to improve developmental outcomes. In one report, 25 % of variance in intellectual performance at 8 years was related to early social stimulation and neonatal behavioral organization (Cohen, 1995). Caregiving interactions have been found to be related to developmental performance throughout the first two years (Beckwith & Cohen, 1989). In addition, interventions that have been the most successful in more optimal development also resulted in interactive synchrony and improved child behaviors (Brooks-Gunn, Kelbanov, & Liaw, 1993).

Infant state that is arousable but does not result in irritable behavior is difficult to maintain in premature infants. Ways to promote better state regulation will improve the availability of these infants for social interaction which is crucial to their emotional and cognitive development (Beckwith & Cohen, 1989). When examining the early social environment for premature infants shortly after hospital discharge, low levels of social stimulation have been found. This may be appropriate early on if the infants become easily over-aroused. Continued low levels of social stimulation however, are not appropriate as child gets older (Holditch Davis & Thoman, 1988).

Premature infants have shown a poorer overall orientation to auditory stimulation which directly relates to cognitive test scores at both 18 months and 5 years (Wallace et al., 1995) and lower amount of maternal vocalization has been related to language delays (van Beek, Hopkins, & Hoeksma, 1994; Vohr, Garcia-Coll, & Oh, 1989). Gradual exposure to maternal voice during hospitalization may be a useful intervention for preventing these problems in the future.

Premature infants ready or not, are thrust into an animated world where there are put into social situations everyday. Expectations of parents and others are that the infants will respond to their efforts to engage them. Extrauterine adaptation includes the ability for receiving human stimulation while learning to process and respond to it.

Early social interactions assist in the development of perception, sensory processing and the formation of relationships. Patterns of less vocalizations between mothers and premature infants that have been repeatedly shown in follow-up studies, probably reflects both the period of separation and the limited responsiveness of premature infants.

There is considerable variability in responses to stimulation and competing stimuli are constantly present. It was difficult to obtain consistent responses across time, but the data have shown dispite inconsistencies, premature infants were aware and responsive to taped maternal voice. The intensity of the response was not measured in this study and may be an important factor to examine. The cumulative effect of even a small response may be beneficial over time.

Conclusion

Maternal voice is a normal part of an infant's environment and is an important source of stimulation for learning. This preliminary exploration of premature infant responses has demonstrated that even premature infants are responsive to their mother's voice.. Controlled, modulated input of maternal voice may potentially increase alerting capabilities and regulation of state making the infants better able to participate in social interaction. Premature infants need not only support for immature system function, but also the opportunity to continue to develop, sensory, motor and social behaviors that will facilitate growth and integration into the extrauterine world as a fully competent and participating member.

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Appendix A: Consent Form

Preterm Infant Responses to Taped Maternal Voice

Investigator: Maryann Bozzette, MN., RN.
Doctoral Candidate in Nursing Science Phone: 206-726-9733

Academic Advisor: Susan Blackburn, PhD., RN.
Professor, School of Nursing, University of Washington Phone: 206-543-8218

Investigator 's Statement

Purpose and Benefits

Many infants are born prematurely each year and are cared for in special care nurseries where they are exposed to many sounds. We currently do not know the immediate responses of premature infants when they hear a human voice or in particular, their own mother's voice. The purpose of this study is to describe the behavior, heart rate response and oxygen saturation levels of premature infants to their mother's voice on tape. This study hopes to explore the patterns of responses that occur in premature infants while hearing their mother's taped voice over a period of three days.

Previous research suggests long term benefits of stimulation on infant development, but the short term effects have not been identified. It is unlikely that you or your baby will benefit from taking part in this study. Information from the study may help health care workers to understand premature infants responses to stimulation.

Procedures

If you choose to participate in this study, you will be asked to read a particular story which will be tape recorded by the study investigator. The tape will be played for your infant four times during the course of the day at routine caregiving intervals which are usually every three hours. The study will last for three days. During a brief period prior to the tape, during the tape, and for a brief period afterward, your infant will be videotaped with a minicamera to capture his/her behavior. Examples of behaviors that will be recorded are whether your baby is asleep or awake, and body movements or facial expressions. In addition, information about your baby's heart rate and oxygen saturation levels which are monitored for his/her ongoing care will also be recorded. Prior to playing the tape, a small felt-covered ear probe with be placed over your infant's ear. This ear probe will assure that your voice reaches your baby's ear, and will allow the tape recorder to be outside of the incubator to cut down on echo from the incubator walls. The volume of the recorder will be kept at a steady level. The cable from the heart monitor will be transferred to another heart monitor that records the information on a computer disk. The study monitor will look similar and your baby's heart rate will continue to be monitored in the same way. If your baby is not on an oxygen saturation monitor, a small probe will be wrapped around his/her foot or hand to obtain the saturation readings. Your baby will be observed during the study for a nine minute period each time. It is expected that each session will take a total of 15 minutes. You may be present during these sessions, but we will ask you not to interact with the baby. In between these brief sessions, you may freely interact and touch your baby and he or she will receive normal care for a premature infant throughout the course of the study. You are also asked to not use an additional tape recorder with your infant during the three day study period. Information from your baby's hospital record such as birth weight and apgar scores will be recorded. Information about your pregnancy, occupation and education will also be obtained either from the hospital record or by interview with you. You may refuse to answer any question.

Risks, Stress or Discomfort

There is minimal risk to a premature infant exposed to tape recorded voice. Loud and prolonged sounds may be uncomfortable for a baby, which is why the tapes will be short and the volume carefully controlled. All study procedures will occur at a time when your baby normally receives care and the only regular expected contact will be to attach and detach the ear probe. The monitor cable is outside of the incubator, and transferring to the study monitor will not require your infant to be disturbed. If at any time during the procedure your baby becomes distressed, the tape will be immediately stopped.

Other Information

You may refuse to participate in this project and may withdraw from the study at any time. If you do, there will be no penalty or loss of benefits to which you are otherwise entitled. Your identity will be kept secret. Tapes from the study will be kept in a locked file cabinet and only the researcher and her supervisory committee will have access to them. Videotapes will be kept for a period of five years and may be used for educational purposes. A summary of the study findings may be reported in academic journals and at professional meetings. There is no cost to you to participate, nor is there is a financial benefit. However, in appreciation for taking part in the study, a copy of the book you will read will be given to you. Thank you for your consideration.

____________________________ ________________

Signature of the Investigator Date

Parent's Statement

The study described above has been explained to me, and I voluntarily consent to participate in this activity. I have had an opportunity to ask questions and understand that future questions I may have about the research project or about subjects' rights will be answered by the investigator listed above. I have been given a copy of this consent form.

____________________________ ________________

Signature of the Parent Date

Copies to: Subject
Investigator's File

Appendix B: Definitions of Behaviors

Facial categories

hands on face: The infant's hands are placed onto his face or over his ears and maintained.

gape face: Drooping of mouth and decreased lower facial tone.

smile: facial relaxation with a slightly upward curving of the corners of the mouth.

mouthing: The infant moves his or jaw in a repetitive opening and closing movement

frown: The infant knits his eyebrows by contracting his periocular musculature.

ooh face: The infant rounds his mouth and purses his lips or extends them as if forming the word "oh".

open face: facial muscles relaxed with high brows raised.

grimace: facial tension with eye squeeze and horizontal mouth stretch.

yawn: The infant briefly closes eyes, and has a long inspiration with mouth widely stretched open.

Motor categories:

finger splays: The infant's hands are open and the fingers are extended and separated from each other.

airplane: The infant's arms are fully extended out to the side at approximately shoulder level.

salute: The infant's arm(s) are fully extended into mid air either alone or simultaneously.

sitting on air: The infant's legs are extended in mid air either one leg or both simultaneously.

Behaviors continued.

hand/foot clasp: The infant grasps or holds onto his own hands or positions one foot against the other.

hand to mouth: The infant attempts to bring his hand or fingers to his mouth.

holding on: The infant actually holds onto the bedding or tubing or other close objects

fisting: The infant tightly flexes his fingers and forms a fist.

jerk: The infant displays an involuntary shudder of entire body.

assumes flexion: Infant actively flexes arms and /or legs.

assumes extension: Infant actively extends arms or legs.

flaccid: Infant appears limp

<u>Attention categories</u>

eyes brighten: The infants eyes are open wide appear to have a shining quality.

eyes wide: The infants eyes are wide open and he is clearly awake.

sucking: The infant sucks on hands, fingers or pacifier

head turn: The infant turns his head on his own in another direction.

stilling: The infants body stops temporally stops movement while the infant is awake.

eyes toward source: Eyes are turned in either a right or left direction as toward something.

fuss: Increased random activity with mild distress. May whimper or whine.

locking: The infant maintains a steady gaze fastened in one direction.
face tone: the infant's face is in a relaxed state with muscle tone present.

Behaviors continued.

hand to ear: The infant actively touches or grasps at ear.

Visceral responses:

sigh: Infant appears to take a deep breath and exhale slowly with relaxed appearance.

gasp: Infant draws in breath quickly and holds briefly as if surprised.

gag: The infant appears to momentarily choke or gulp.

hiccough: A rhythmic spasm of the glottis and diaphragmatic muscle.

spits up: Infant vomits or regurgitates milk or saliva.

burp: The infant brings up air in an expiatory burst.

*Adapted from Als, 1986

Appendix C: Blackburn Activity Scale for Premature Infants

CODE	ACTIVITY
0	no activity
1	facial movement only
2	hand/feet movement or twitch
3	head or entire extremity movement only
4	mild trunk movement
5	moderate trunk movement
6	writhing/thrashing
9	unable to code and/or see infant

Blackburn, 1991

Appendix D: Infant States

States labeled as A are noisy or more diffuse. B states are clean and well defined.

State 1A: Infant in deep sleep with momentary regular breathing, eyes closed with no movement under lids. May have isolated startles or tremors.
State 1B: Eyes closed with regular breathing and no movements under lids, body is mostly still.

Sate 2A: Light sleep with eyes closed, rapid eye movements, diffuse or disorganized motor movements, respiration are irregular. Sucking or mouthing movements, whimpering, grimacing and facial twitches may be seen.
State 2B: Light sleep with eyes closed rapid eye movements under closed lids, low active level with movements or startles, facial twitches or grimacing.

State 3A: Semi-dosing with eyelid fluttering. If ayes are open may have a glassy veiled look. Diffuse movement with mild fussiness; whimpers with facial grimacing may be seen.
State 3B: Drowsy or semi-dosing, eyes may be open or closed, whimpers or grimacing may be noted, but with less motor discharge.

State 4AL: Awake and quiet, may have a dull or glazed look, infant may close eyes intermittently.
State AH: Awake and quiet with minimal motor activity, Eyes wide open with "hyperalert" look. Infant may be unable to break the intensity of fixation on an object.
State 4B: Awake and quiet, minimal motor activity. eyes bright and shining.

State 5A State is awake and aroused, with increased motor and tonus. Fussing, if present is diffuse or strained.
State 5B: Infant is awake and aroused and displays motor activity and fussing behavior.

State 6A: Intense crying, may be strained or weak.
State 6B: Rhythmic, intense, robust crying.

Adapted from Als, 1986

Appendix E: Demographic Data Collection Sheet

Infant code ______________

Infant Data

Date of birth________________ Male_______ Female__________

Dates of study_____________ Gestational Age______________

Birth weight___________g Apgar score 1______ 5______

Maternal Information:

Parity________Gravity__________Age at delivery__________

Type of delivery: Vaginal_______ forceps_______ vaccum______

Cesarean section___________

Pregnancy course____

____

Labor course____

____

____

Delivery____

____

____

Background:

Father's occupation________________________________

Mother's occupation_______________________________

Mother's education in years________

Father's education in years___________

Ethnic origin of mother: Caucasian_______Hispanic________

African-American_______American Indian________Asian_________

Ethnic origin or father: Caucasian________Hispanic__________

African-American_________American Indian__________

Appendix F. Clinical Data Sheet

Infant code________________

Date______________________ Weight________________gms

Current Diagnosis: ______________________________________

Supplemental oxygen status:

Ambient oxygen concentration_____________

Mode of Delivery Hood____Nasal Prongs____ CPAP____

Cranial Ultrasound (if applicable) Grade 1____ Grade 2____PVL ____

Medications:

Type___________ Route_____Frequency______Reason_________

Type___________Route______Frequency______Reason_________

Type___________Route______Frequency______Reason_________

Type___________Route______Frequency______Reason_________

Nutrition:

Feeding interval_________ Formula_____ Breastmilk_______

Enteral route: oral______nasal_____ continuous______ bolus_______

Phototherapy yes_______ no_____

IV yes______no_______ site_____________

Procedures required____

____

____

Bedside conditions

Light____

Sound____

Activity____

Clothing: hat______ shirt________diaper_________ booties_________

Bedding: sheepskin_____side rolls______foot rolls______

Other:____

Describe any events occurring during procedure:_______________________

____

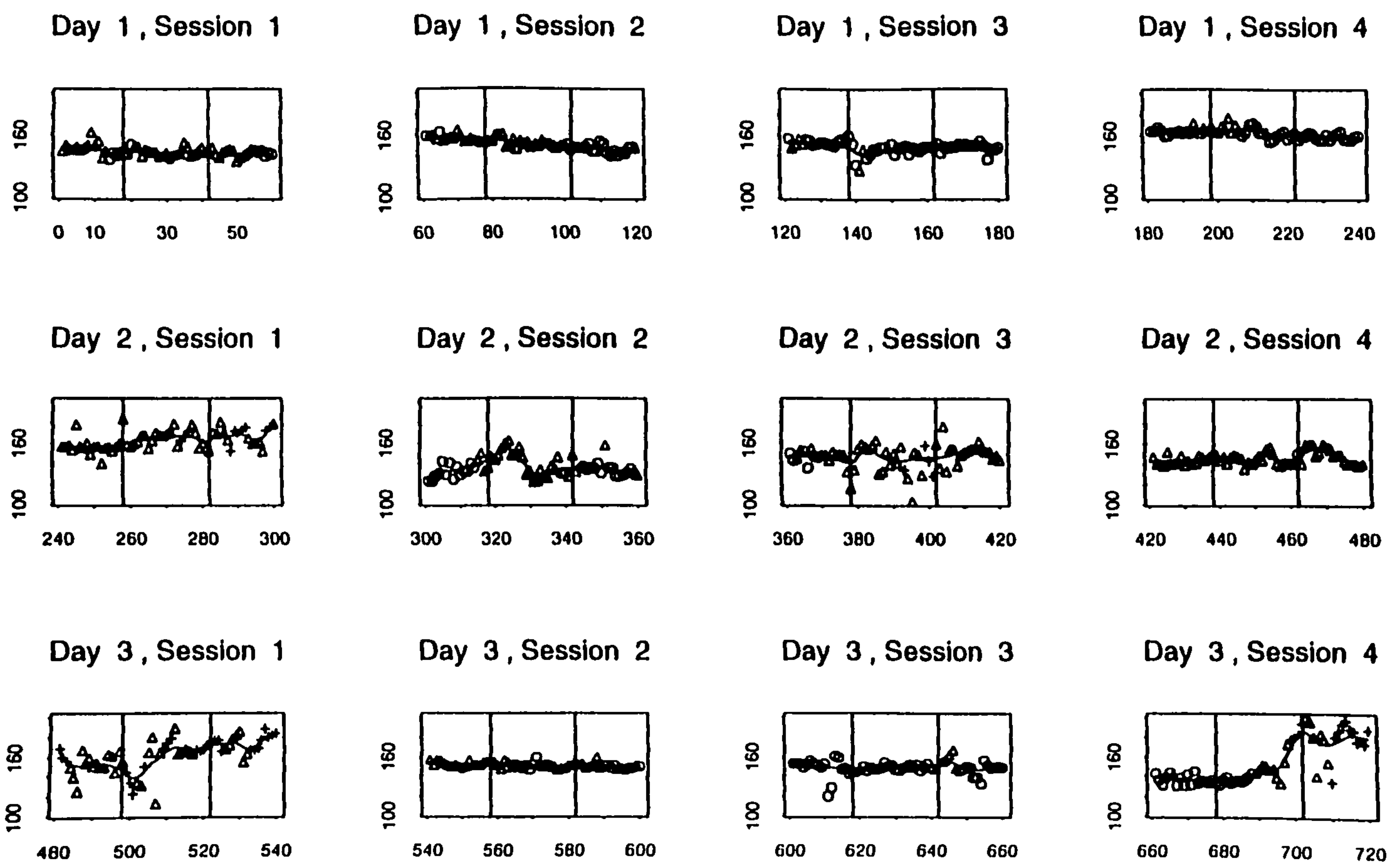
____

____

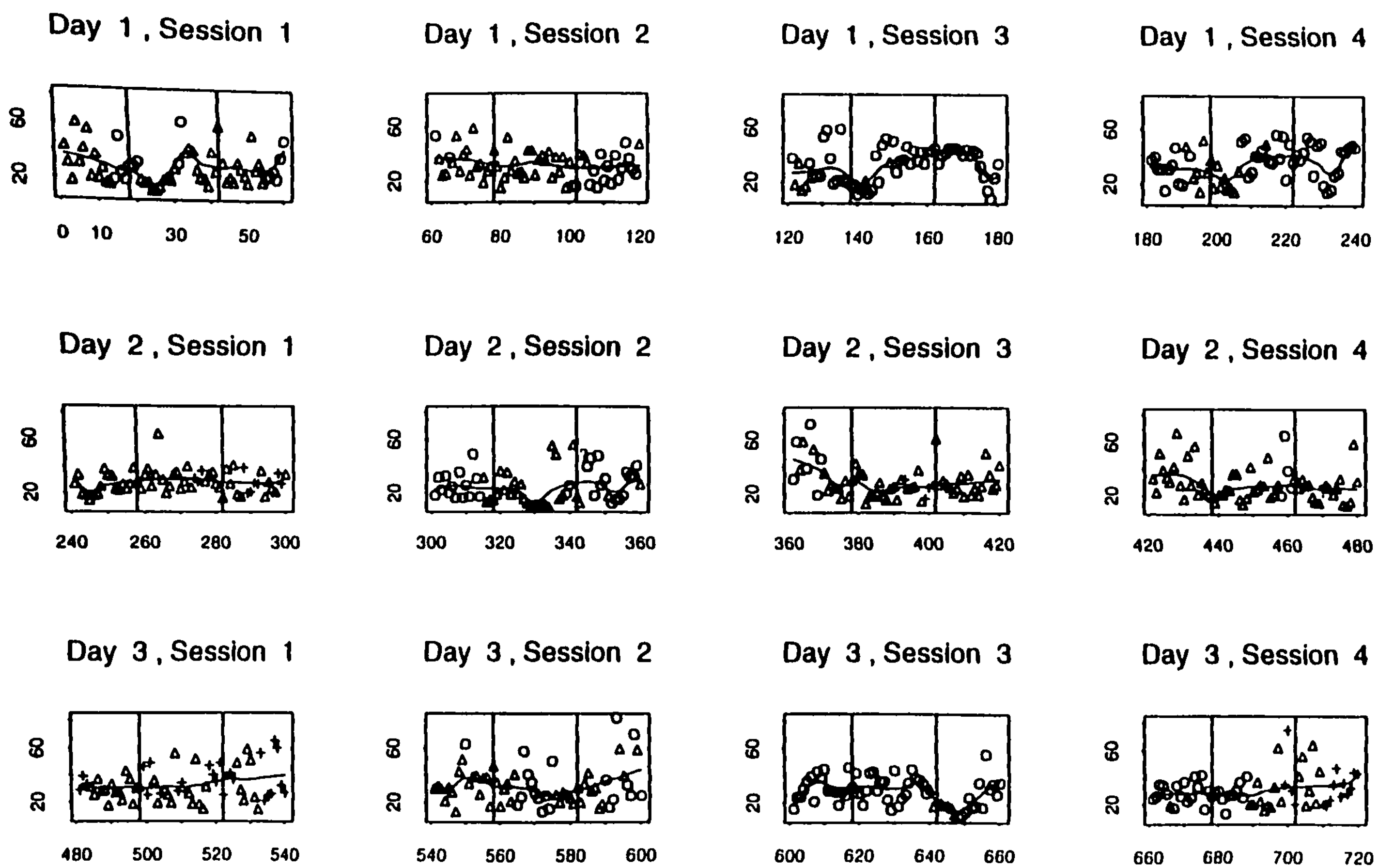
Appendix G. Graphic Representation of Each Subject over the 12 Sessions Plotted by Major Infant State Category by Day & Session

n=36
Each data point indicates 10 second intervals
Each session is divided by segments
Δ=awake
+=crying
o=sleeping

Subject 1. Heart Rate by Segment for All Sessions



Subject 1. Respiratory Rate by Segment for All Sessions



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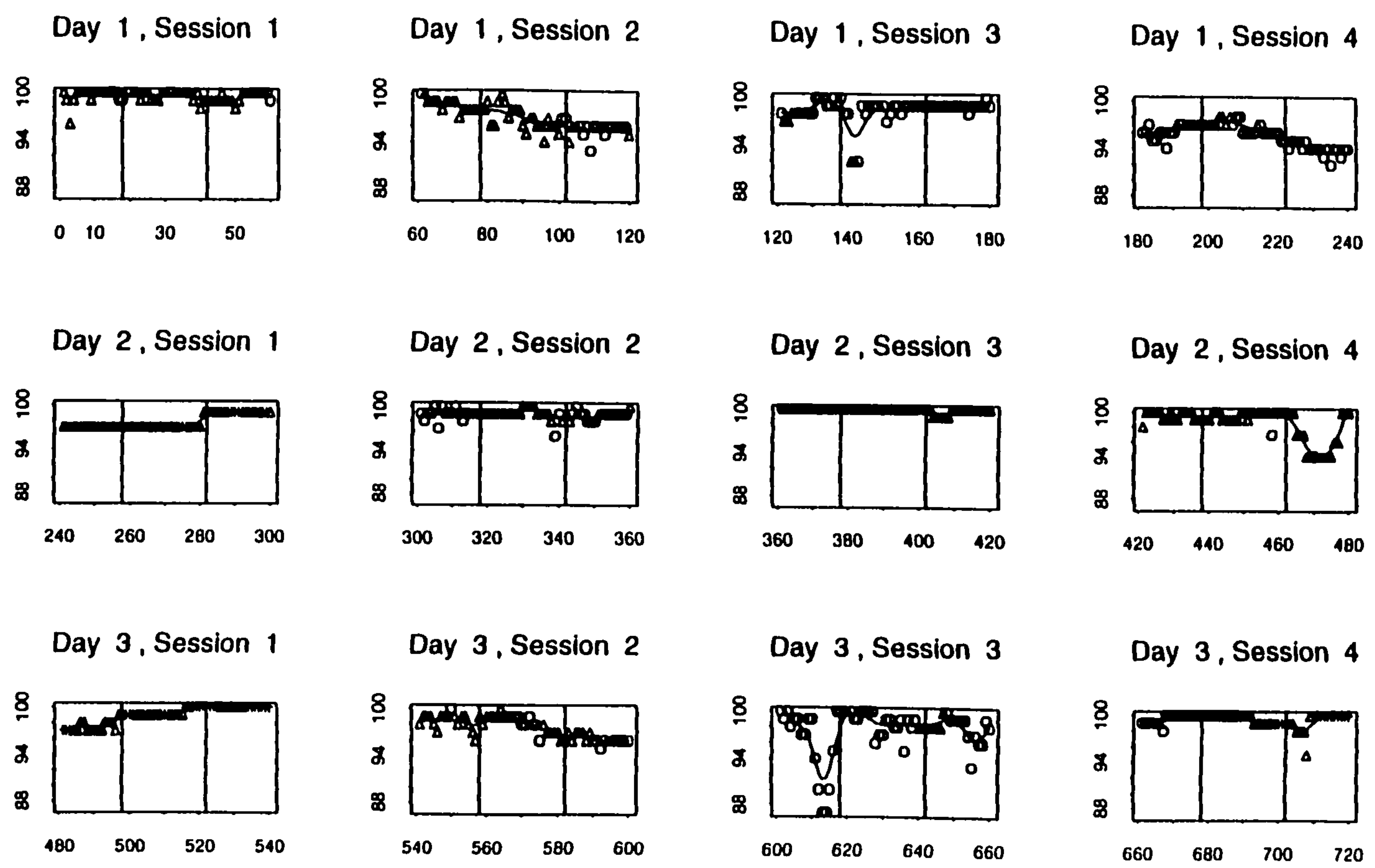

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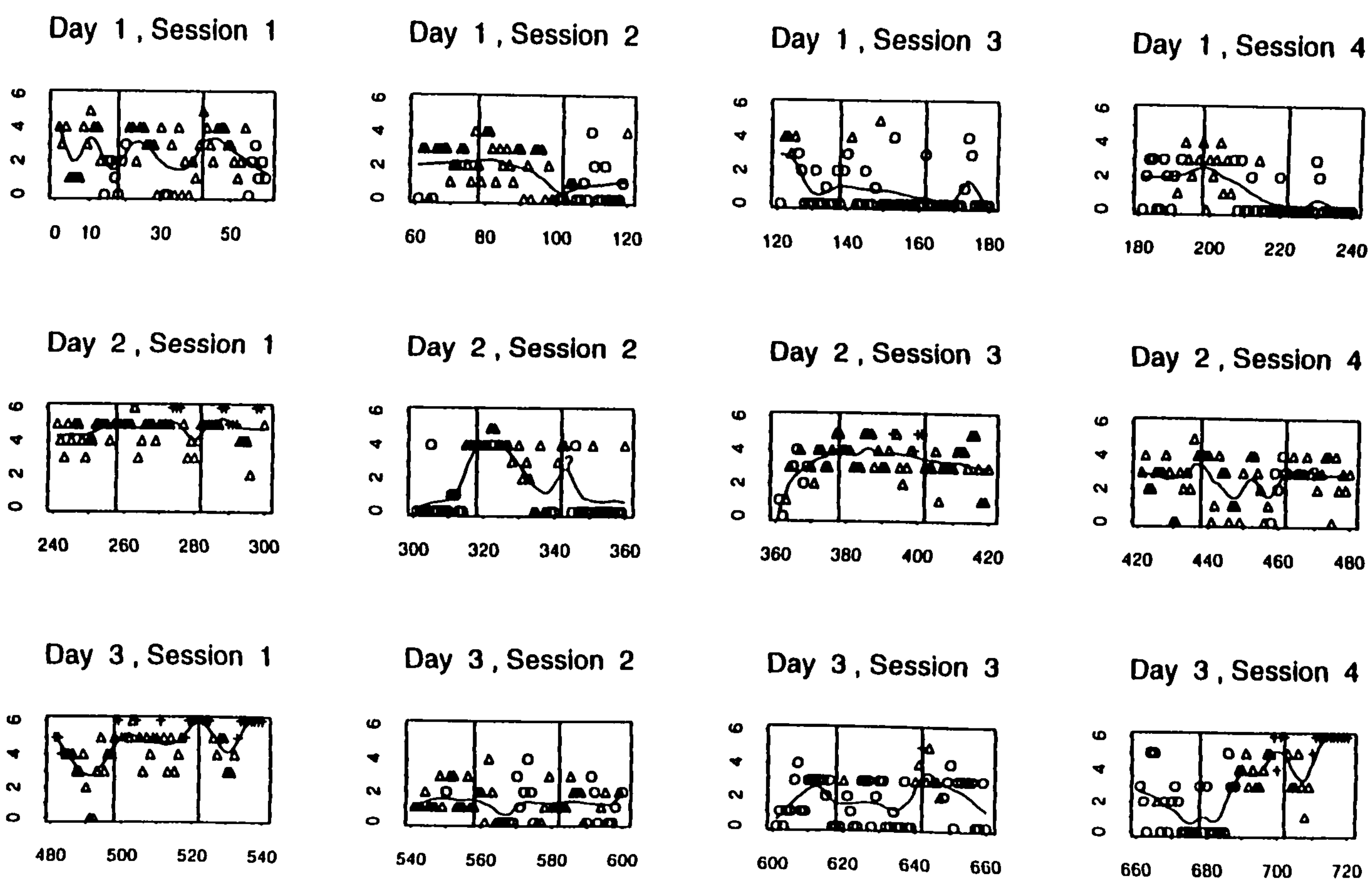

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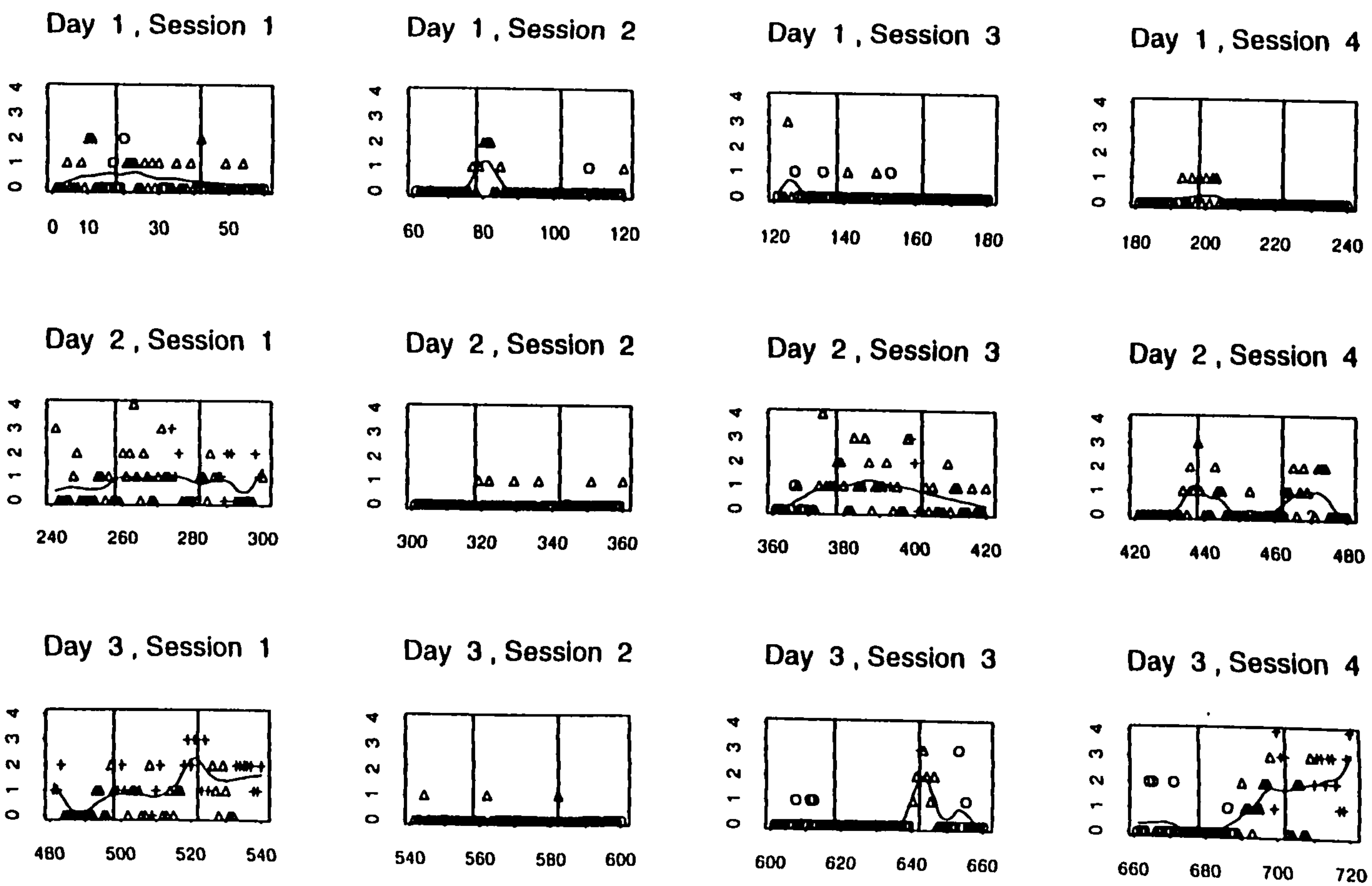

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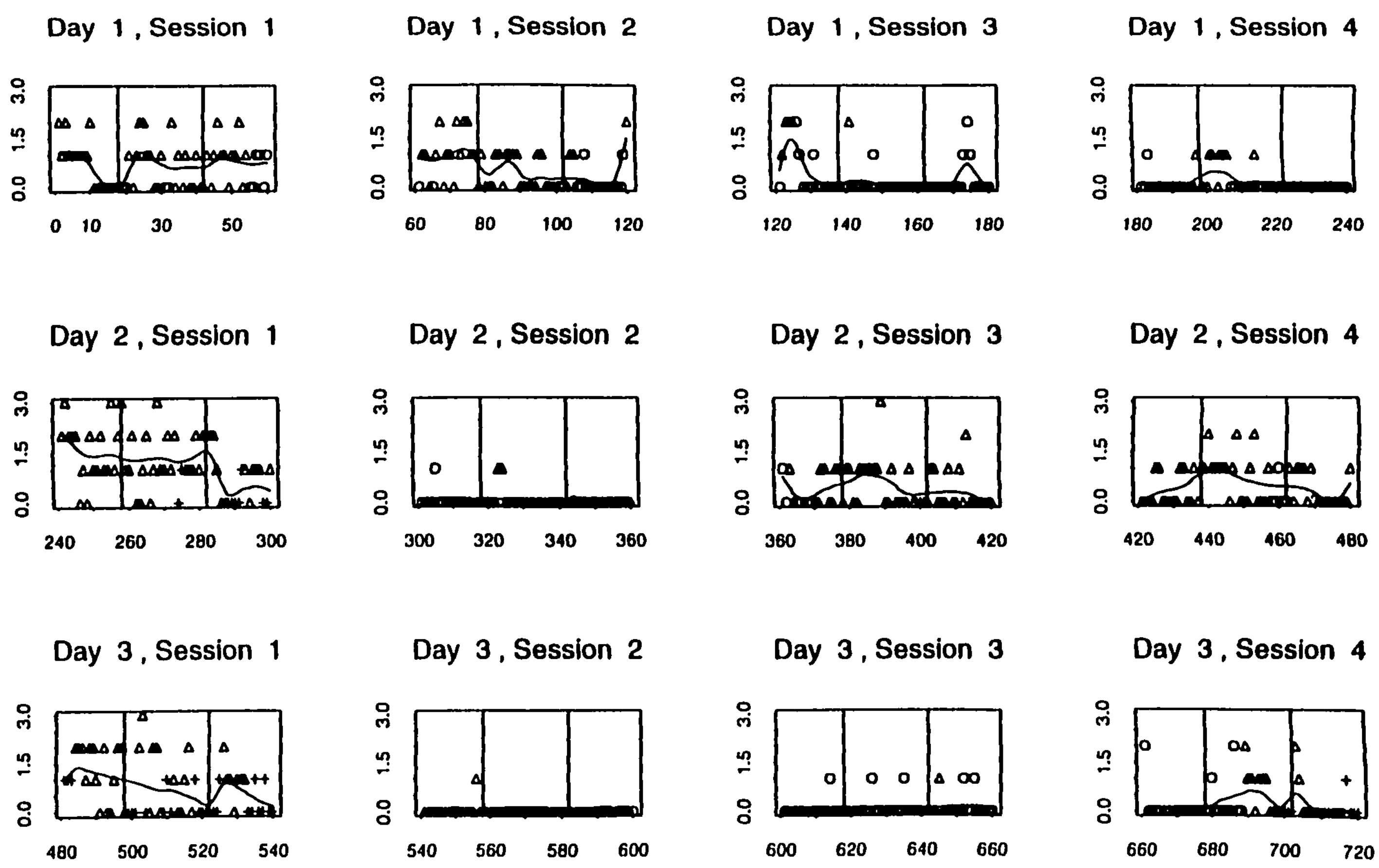

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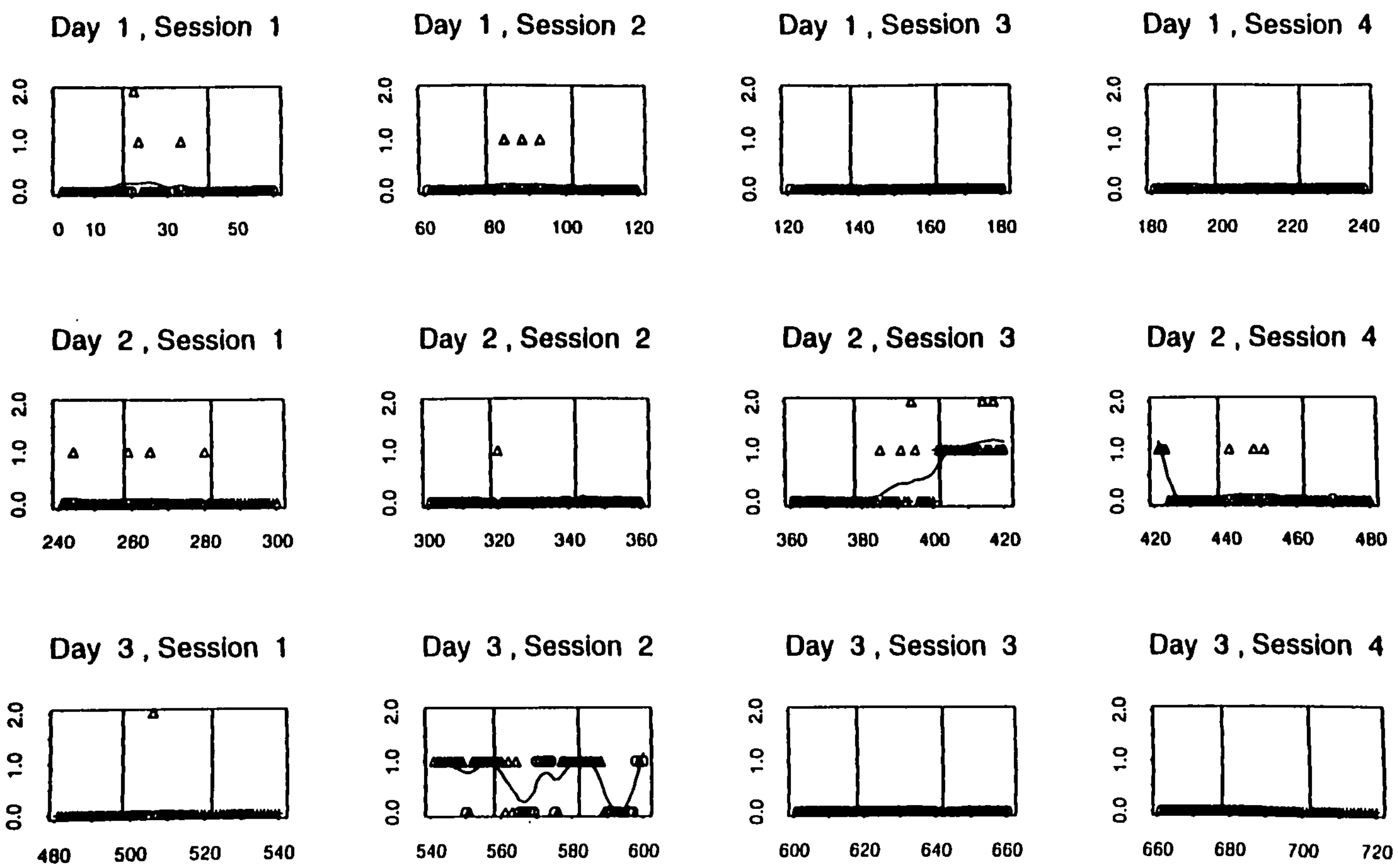

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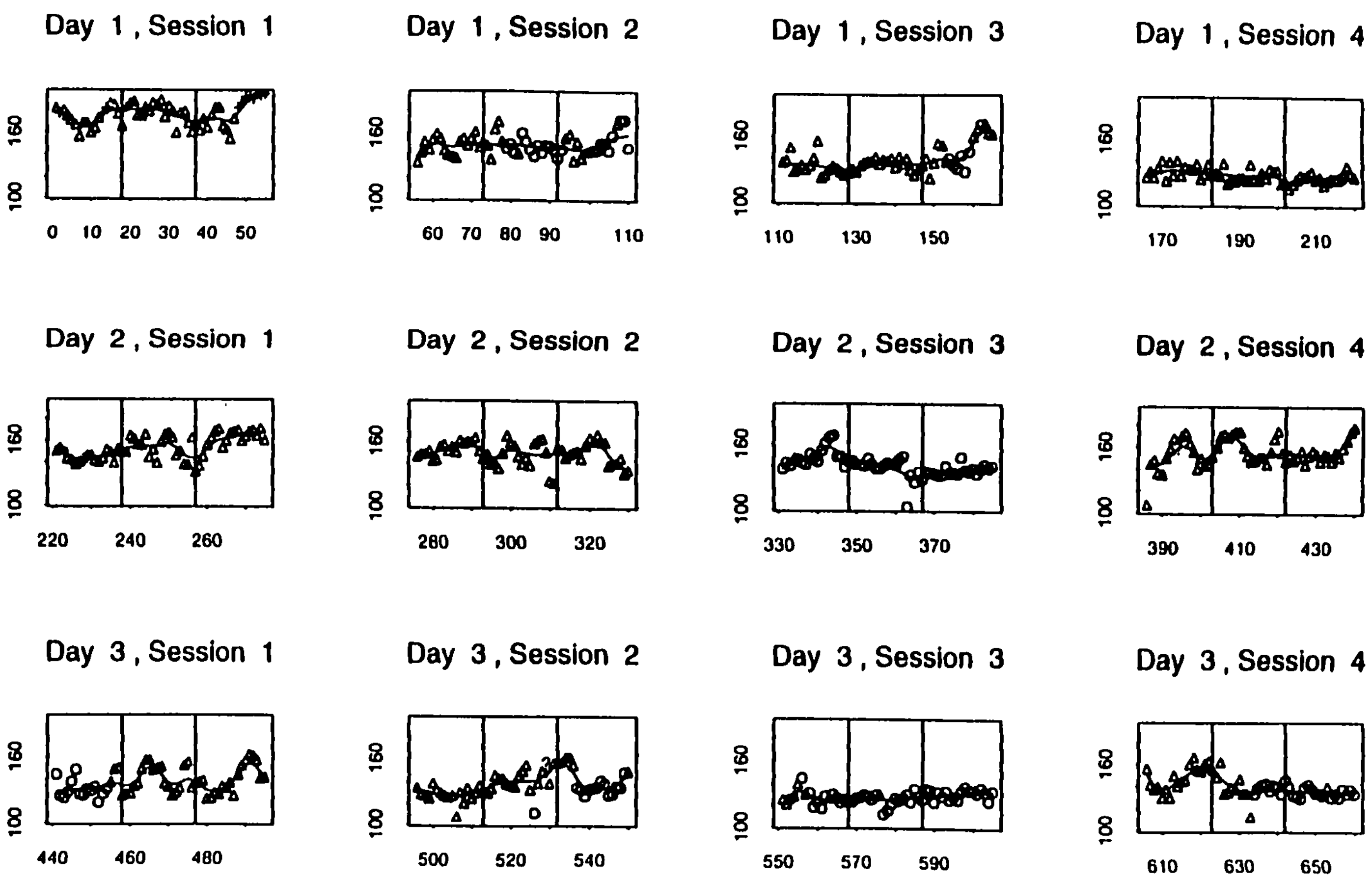

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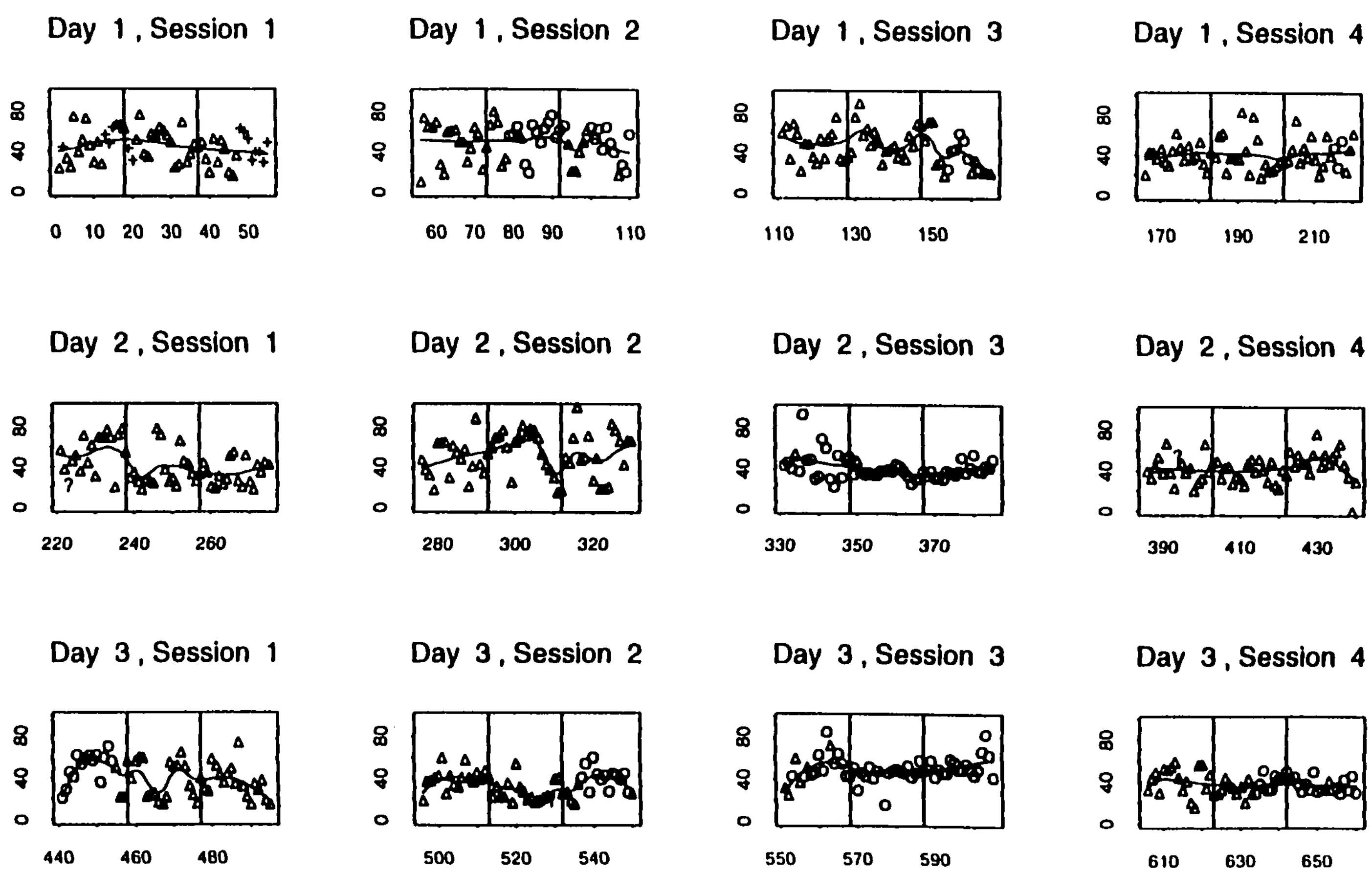
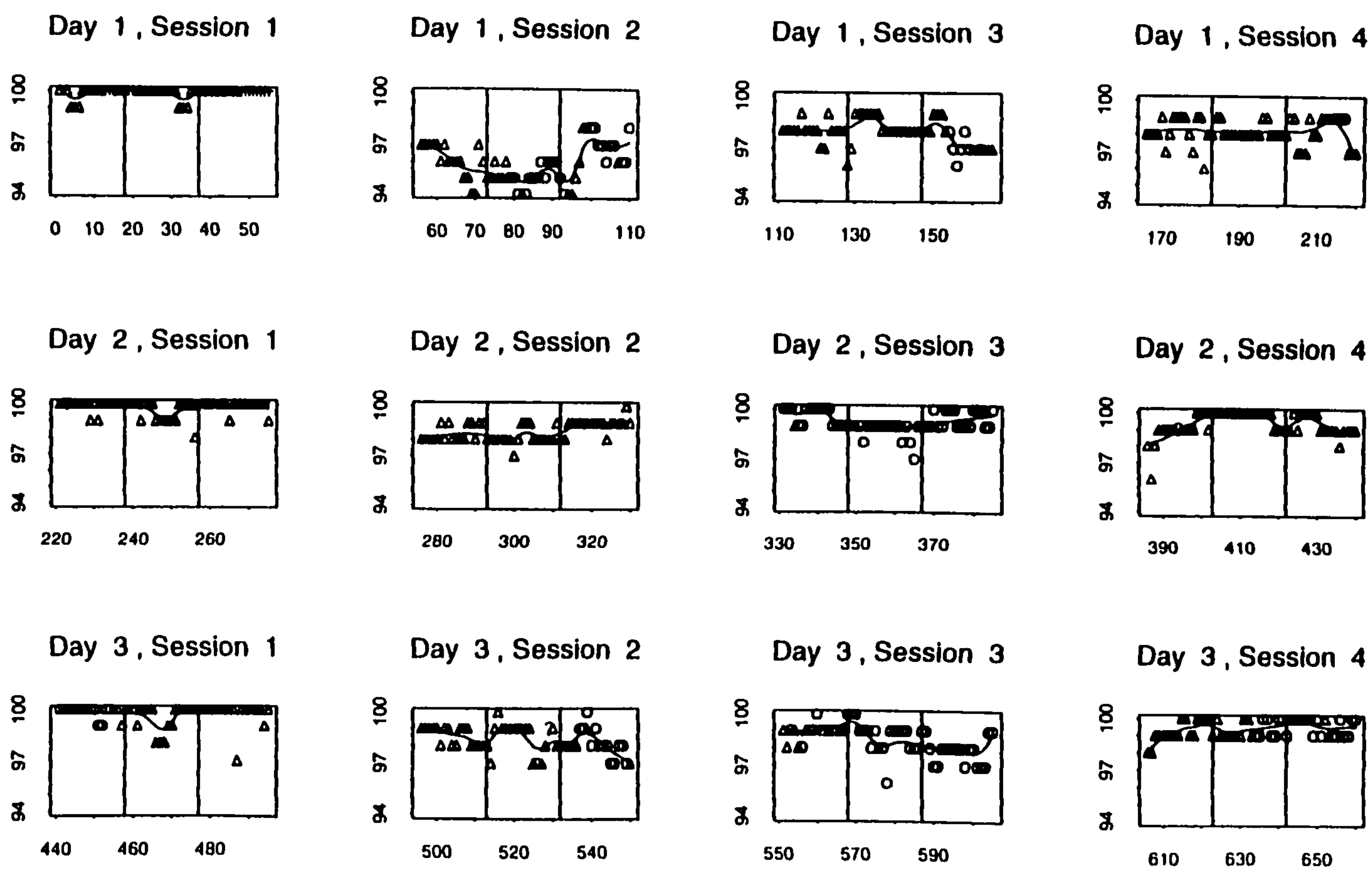


Subject 2. Oxygen Saturation by Segment for all Sessions



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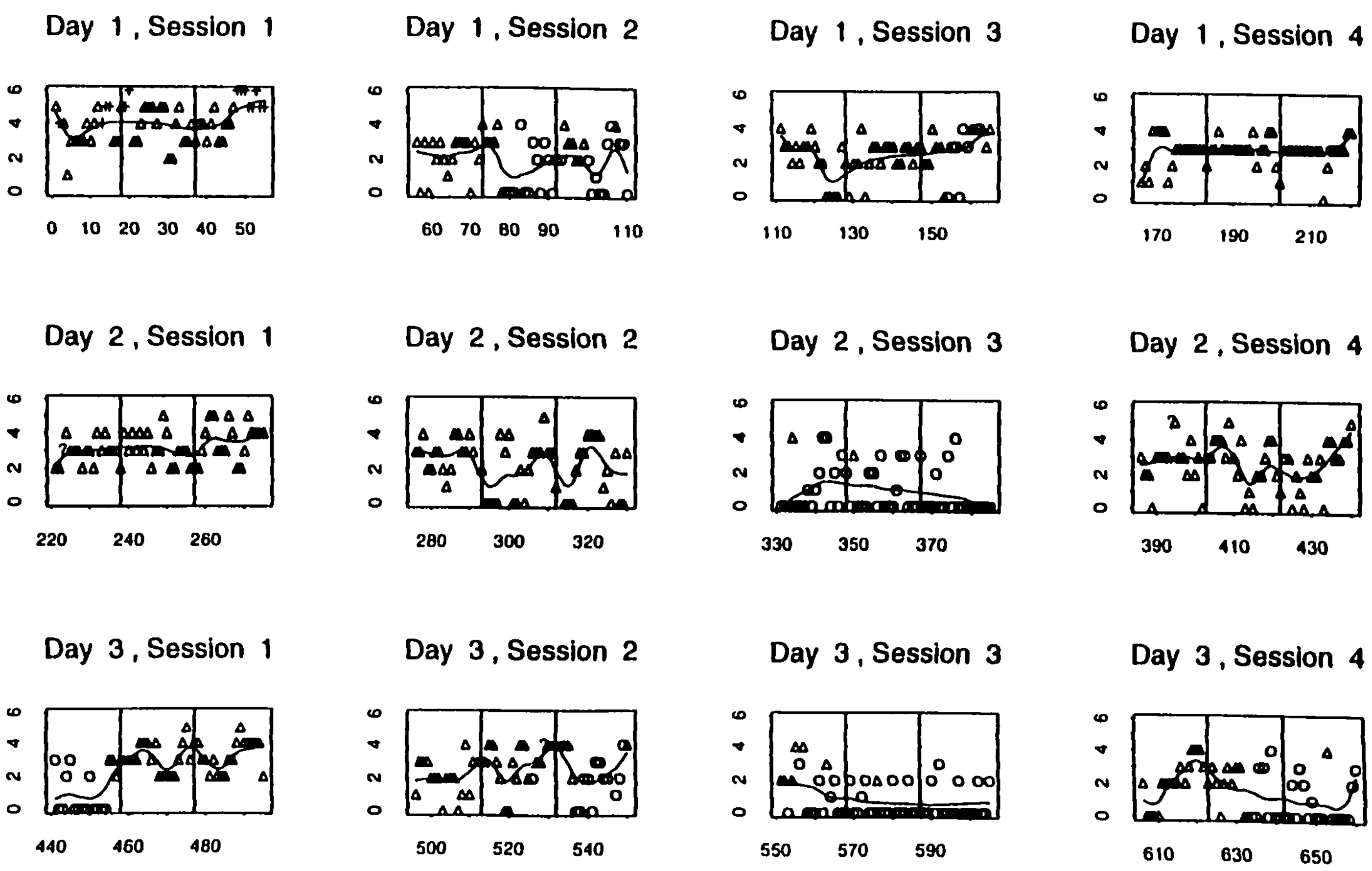

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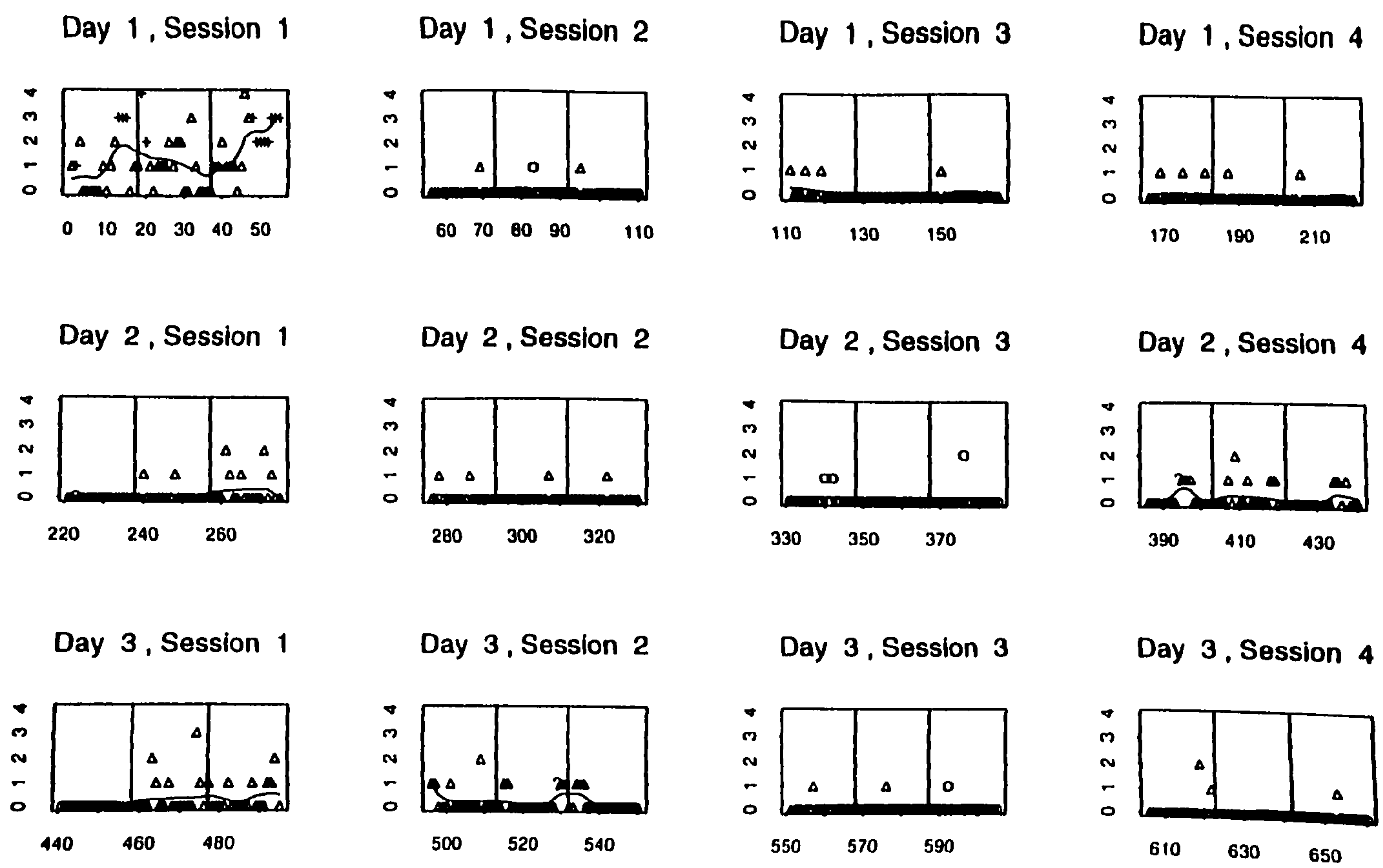

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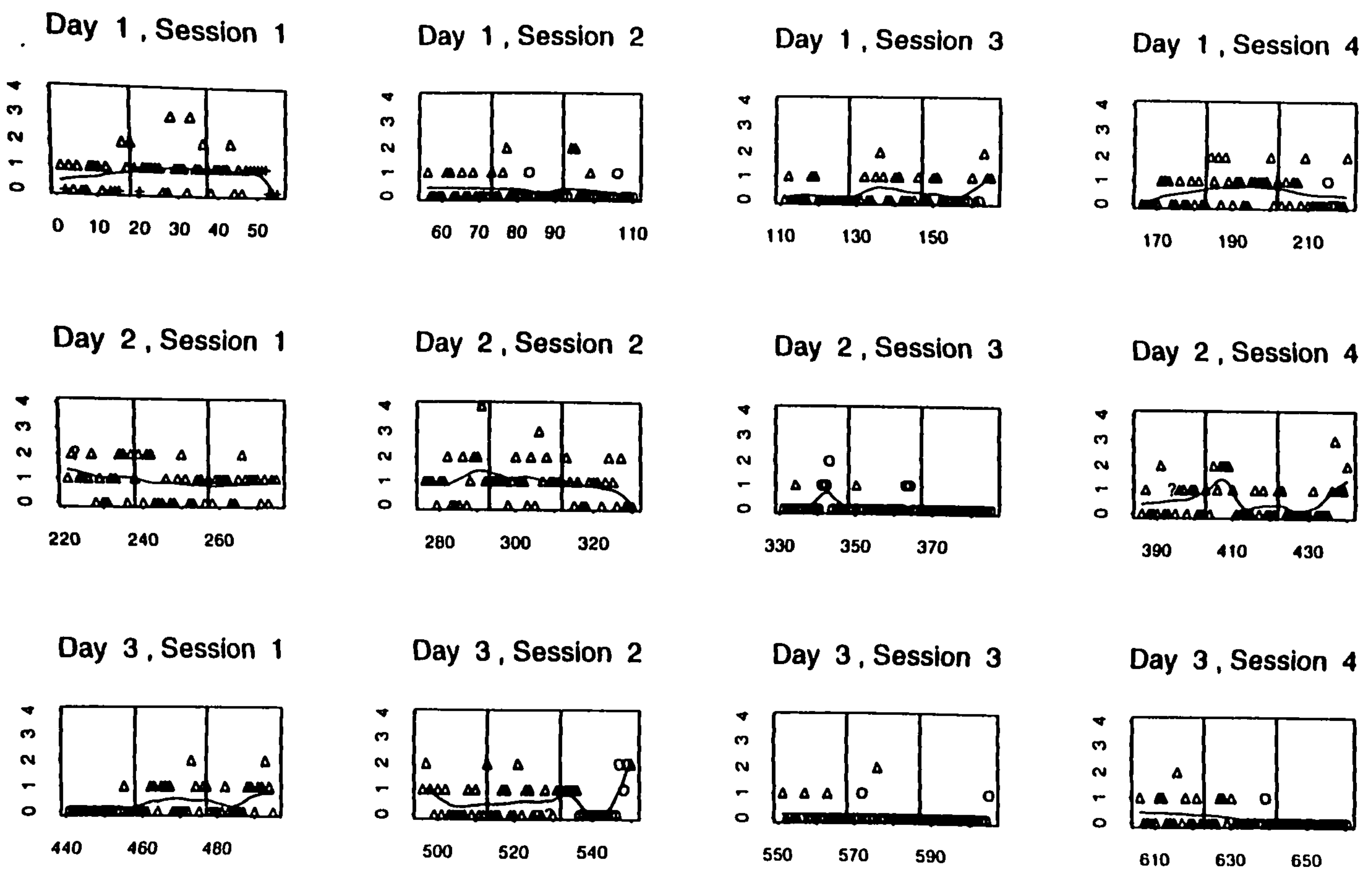

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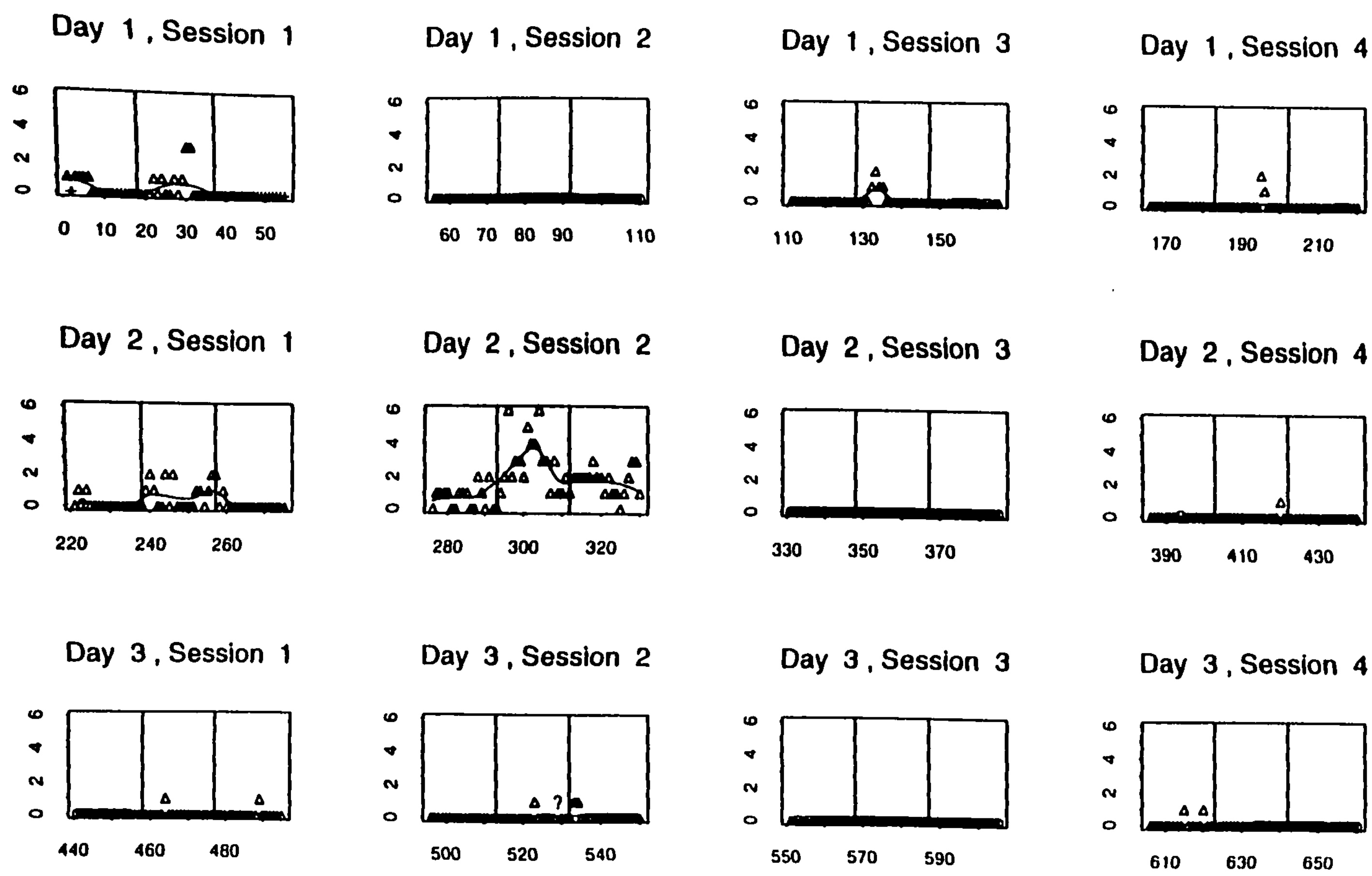
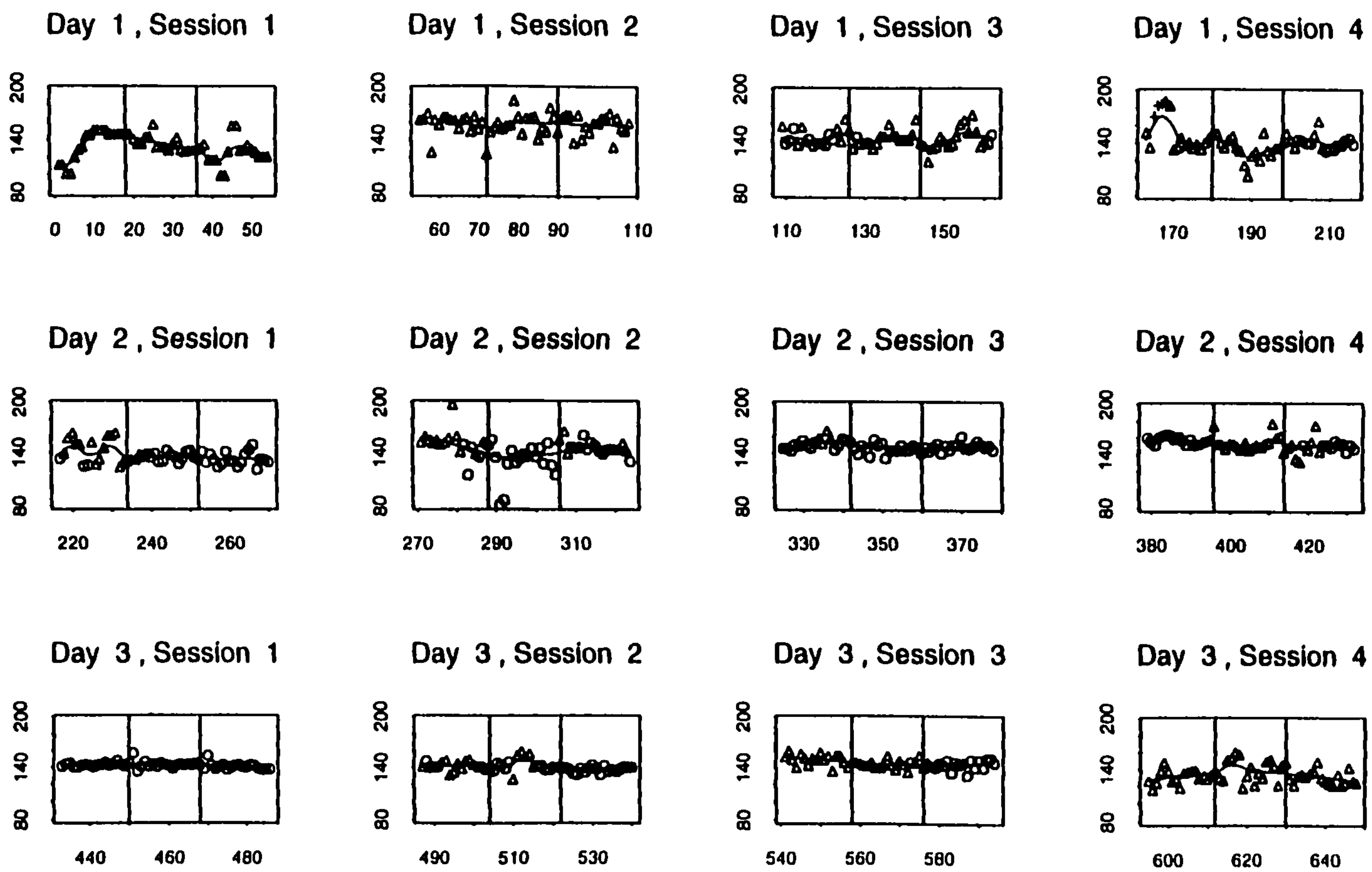


Subject 3. Heart Rate by Segment for All Sessions



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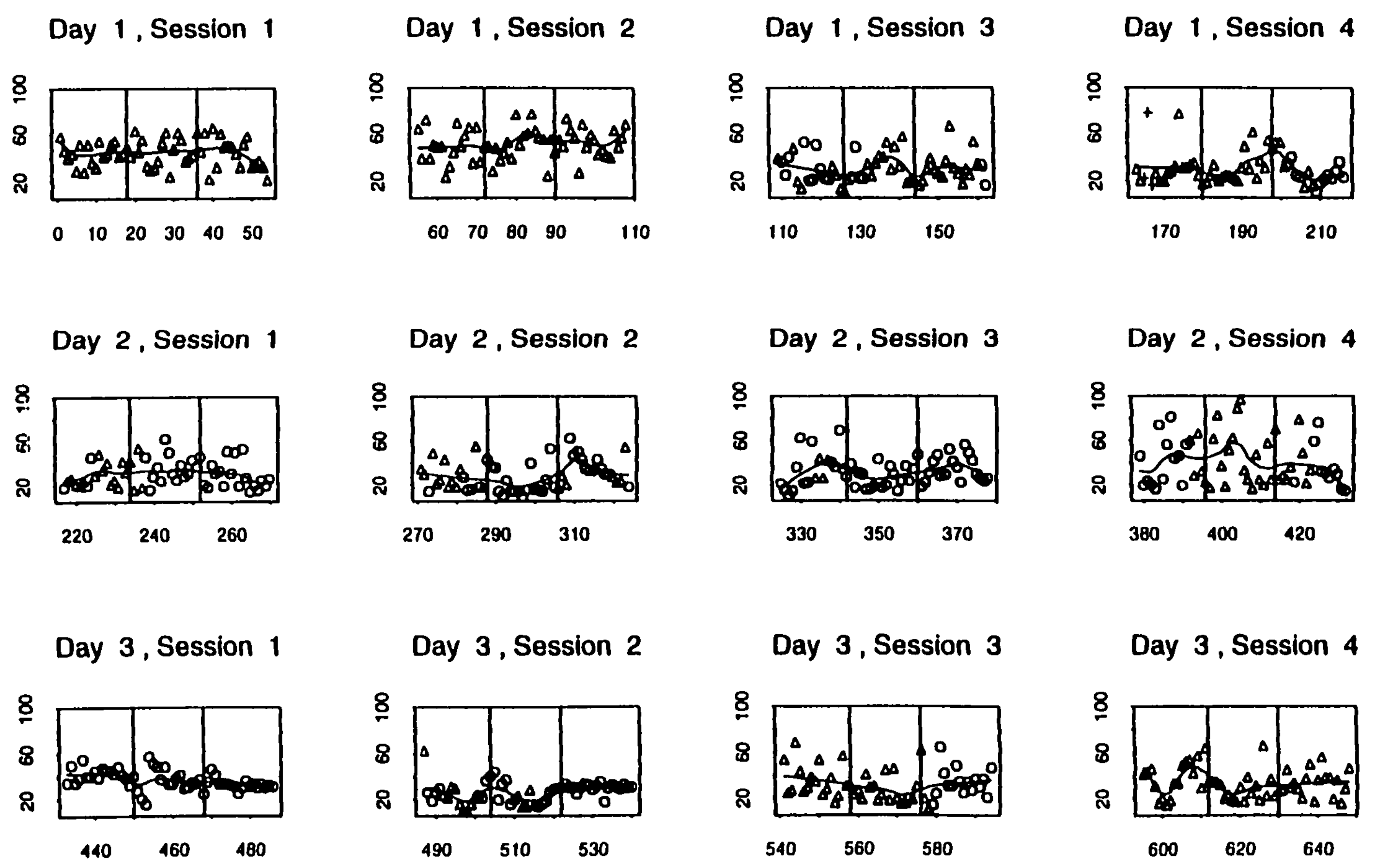
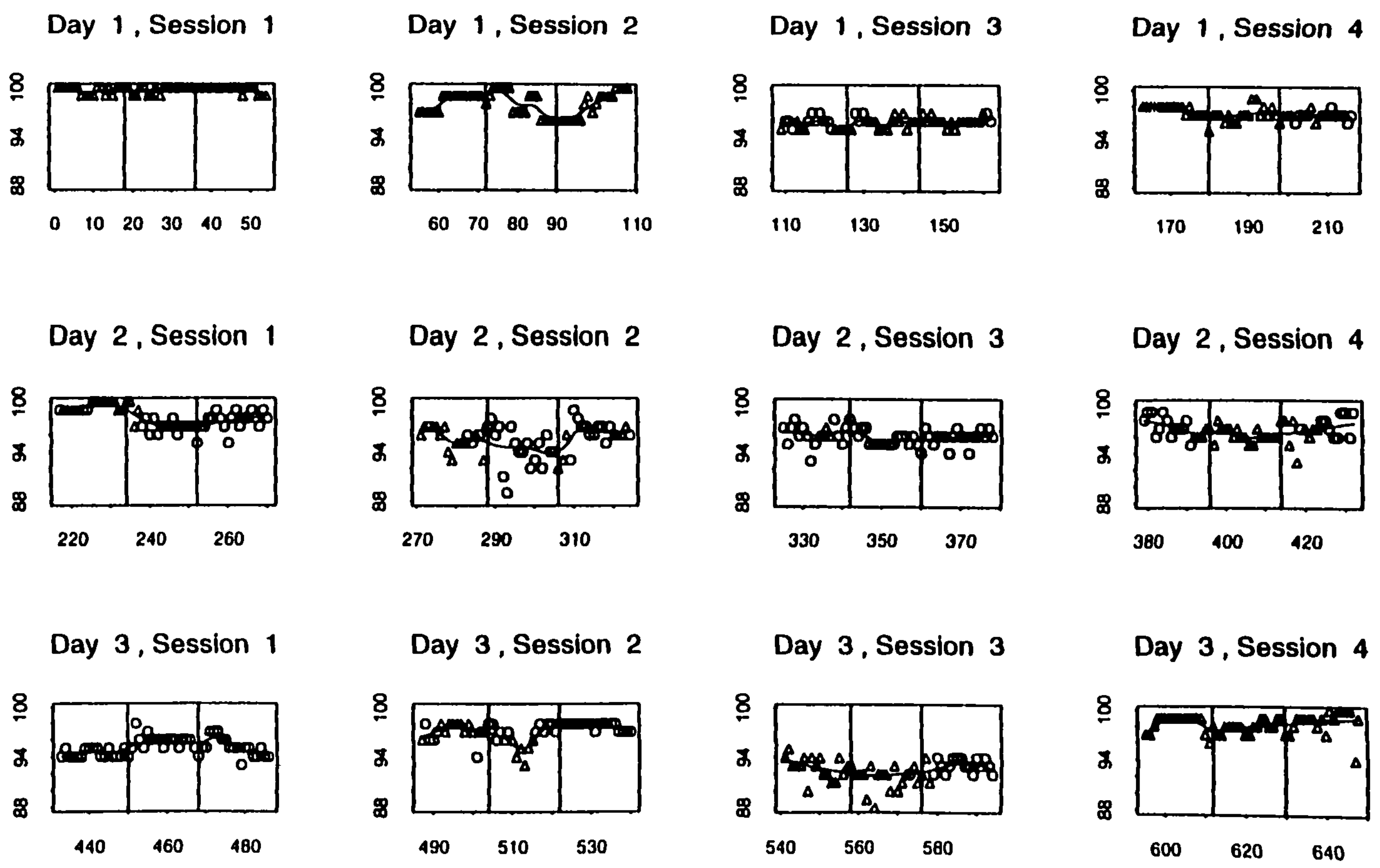


Subject 3. Oxygen Saturation by Segment for All Sessions



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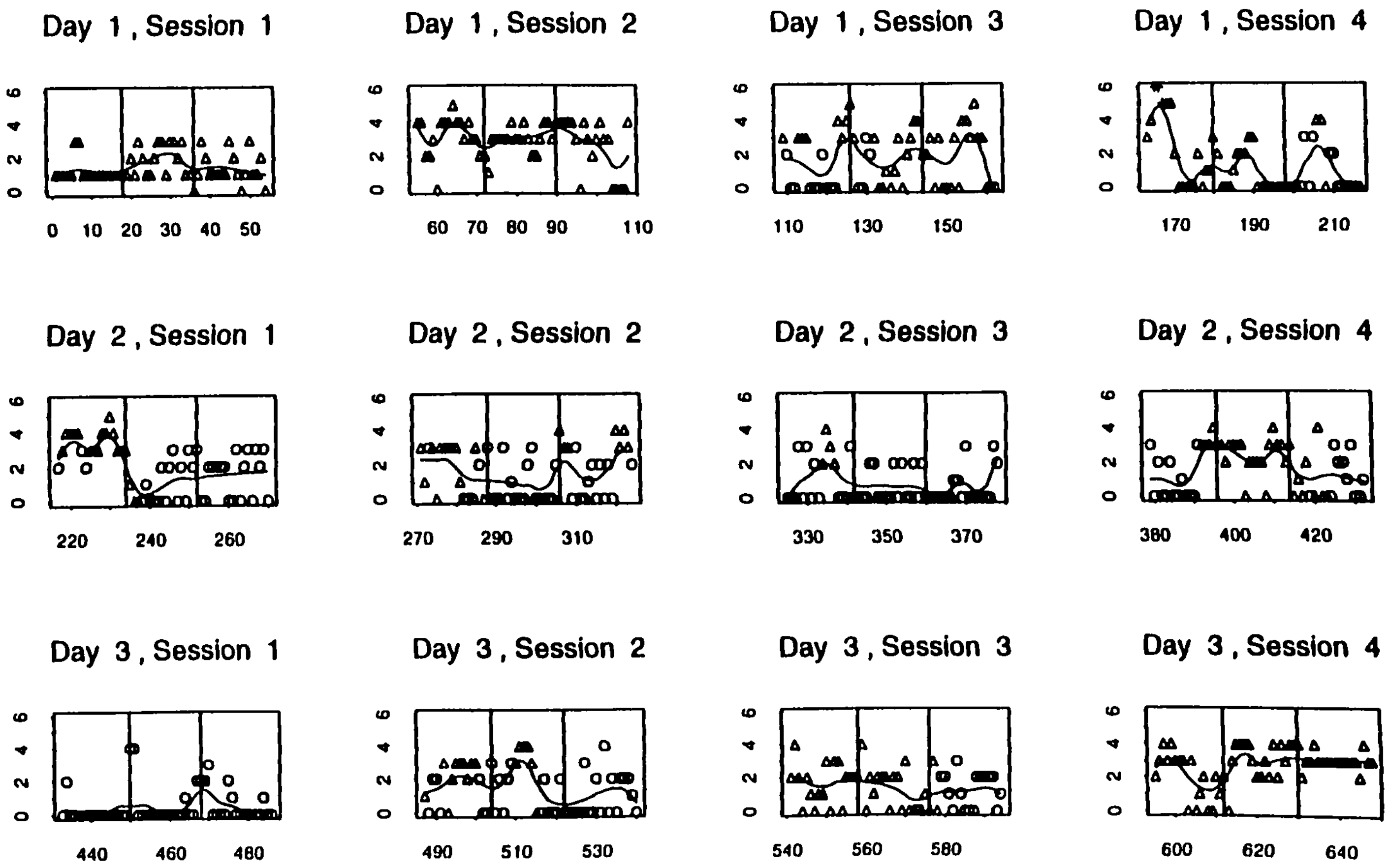

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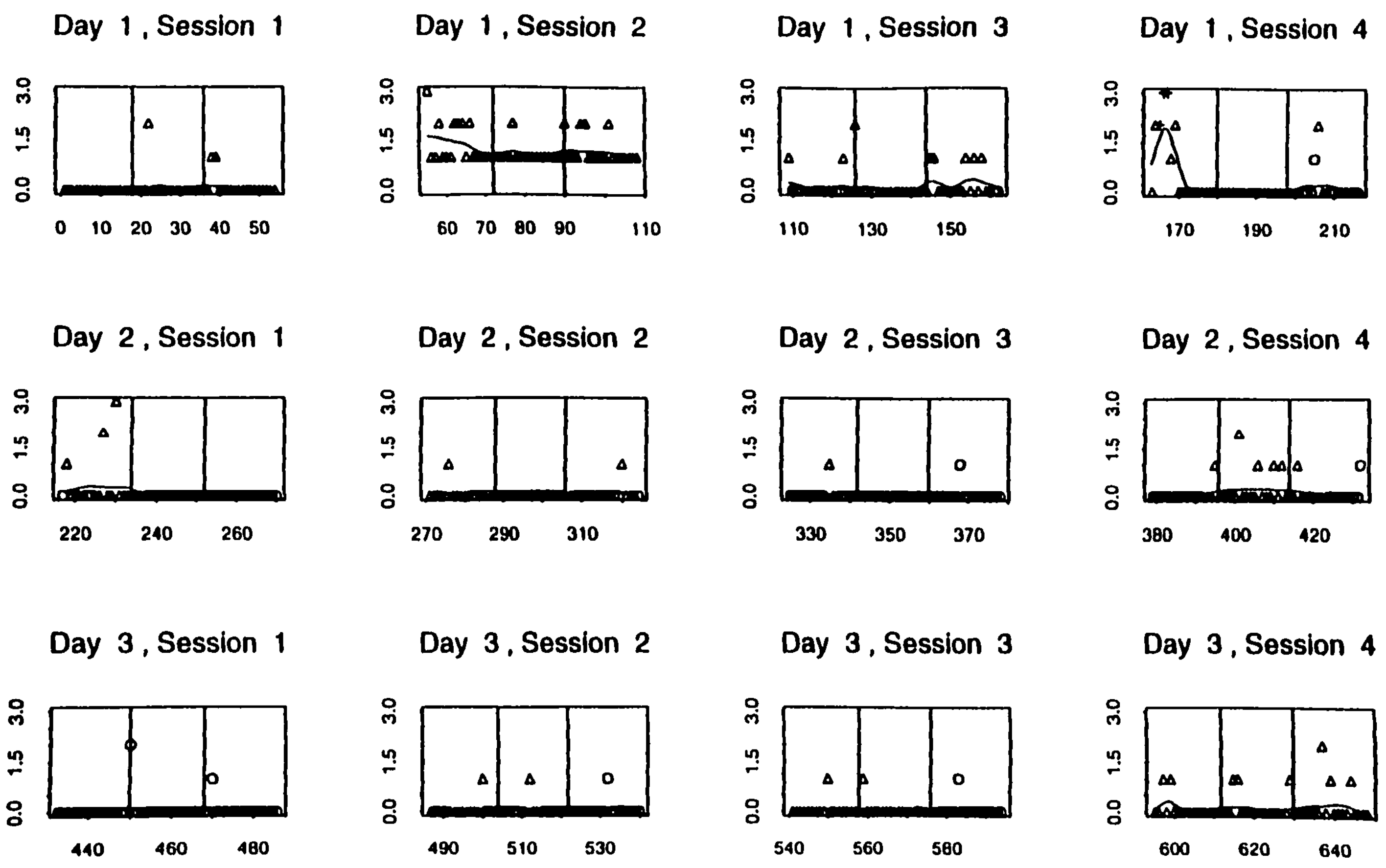
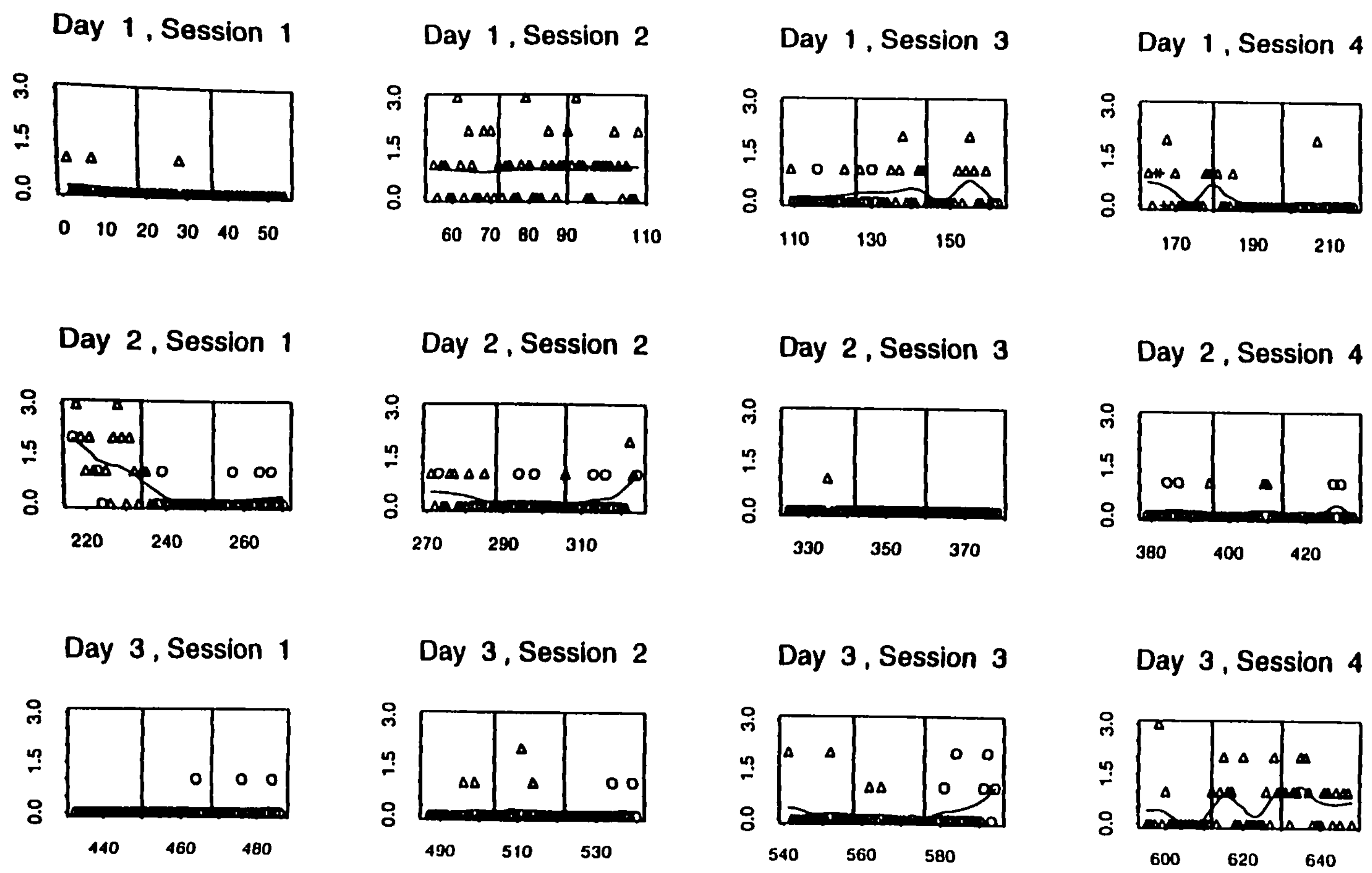
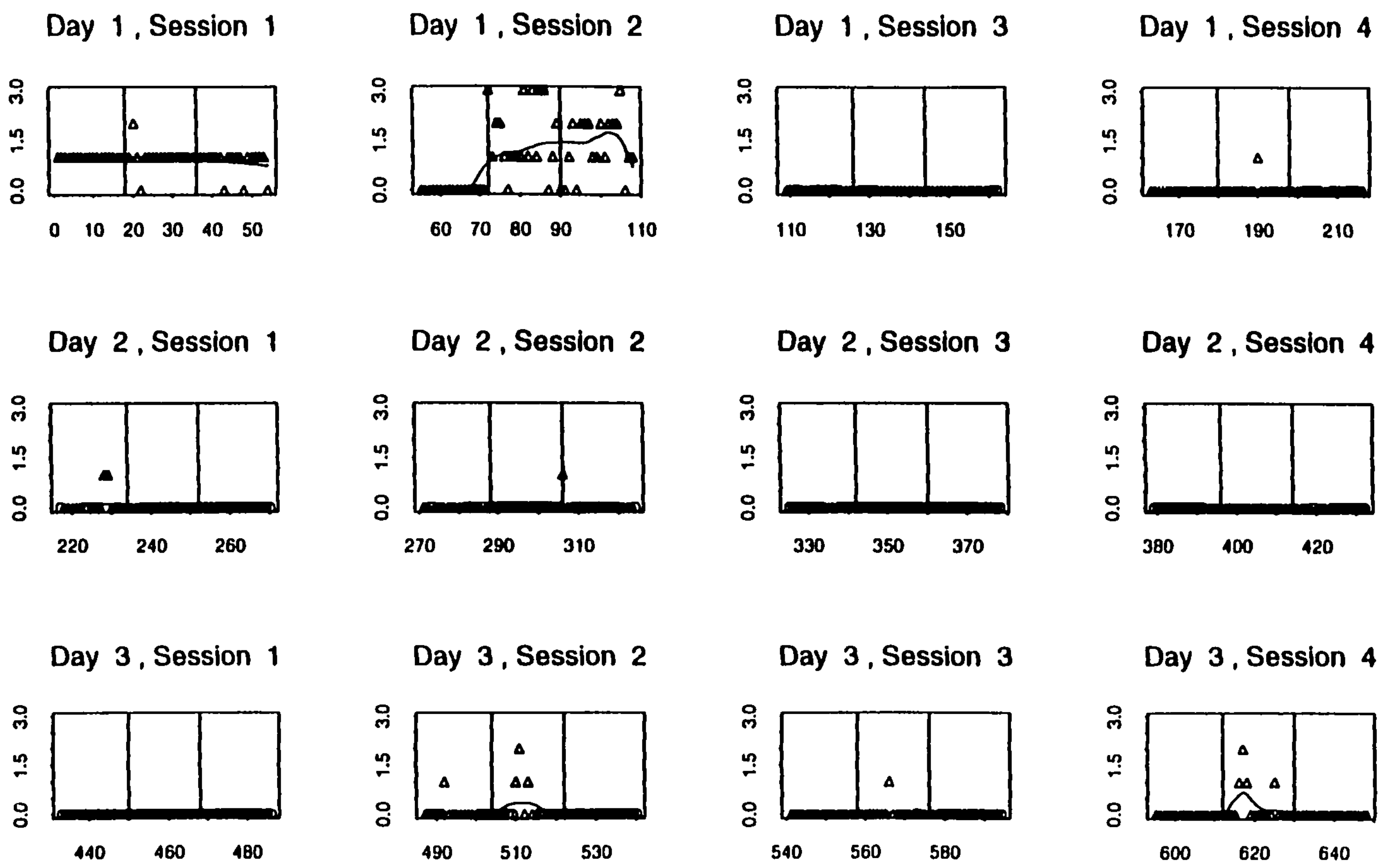


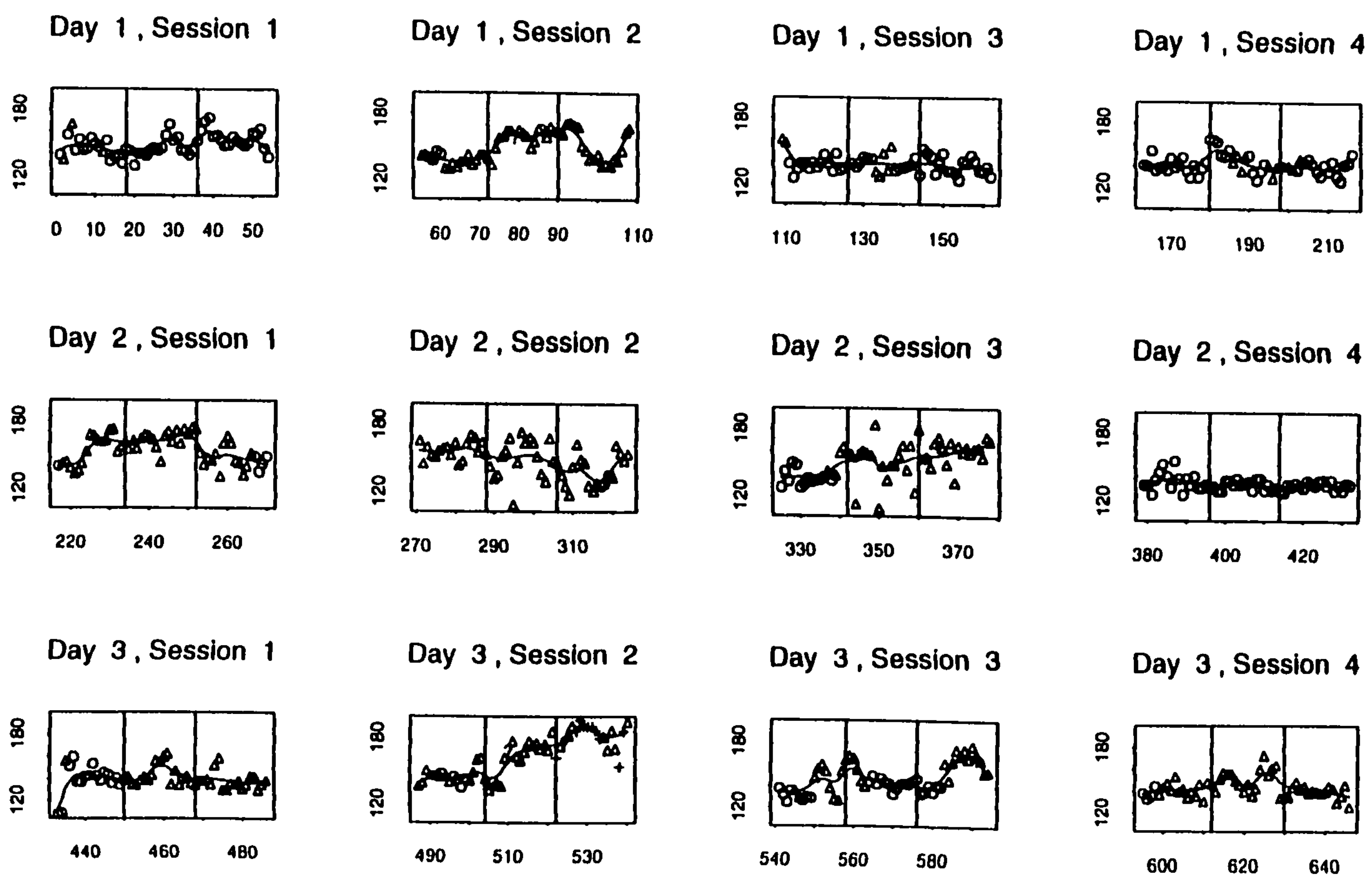
Subject 3. Stability Score by Segment for All Sessions



Subject 3. Attend Score by Segment for All Sessions



Subject 4. Heart Rate by Segment for All Sessions



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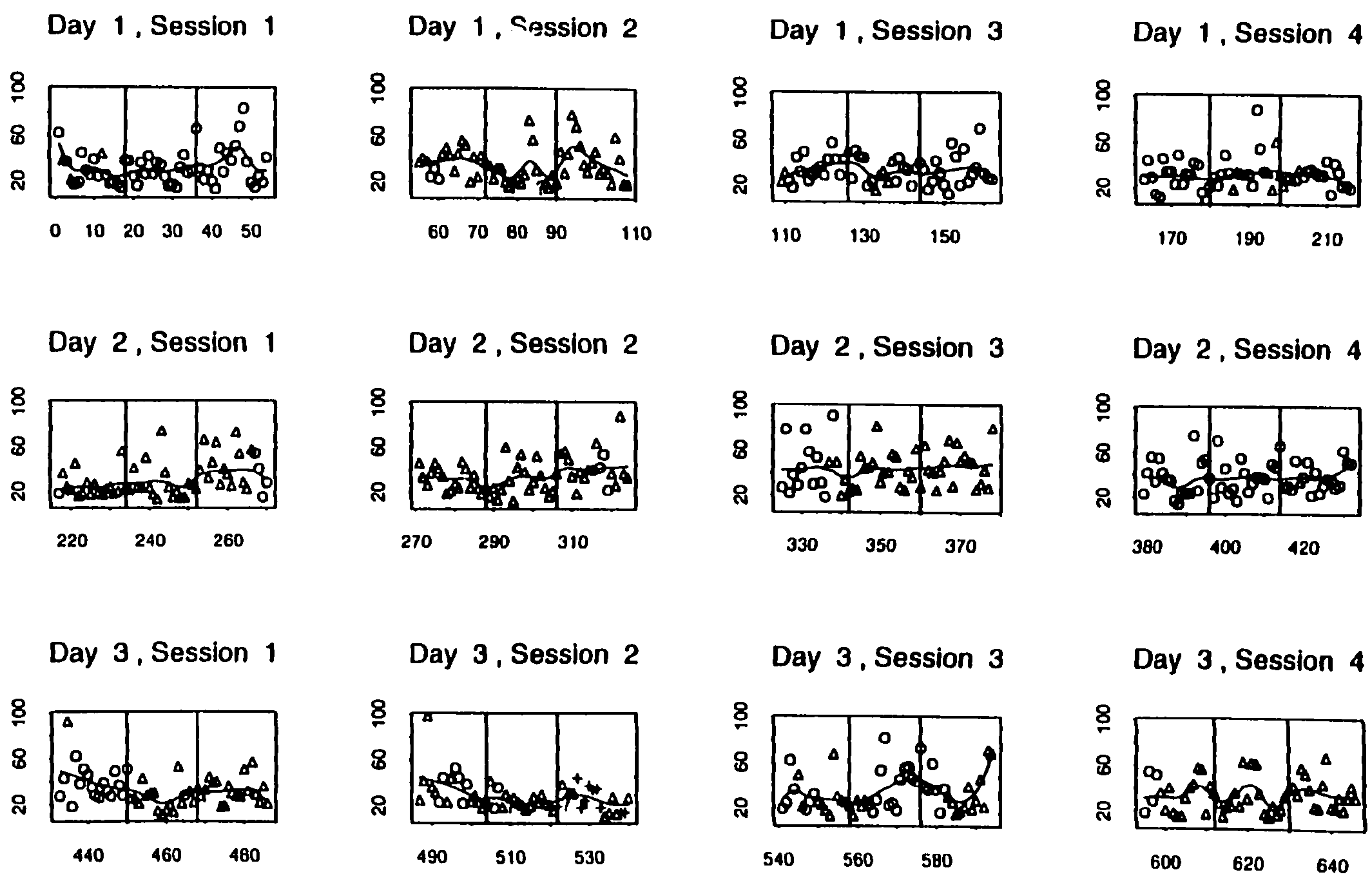
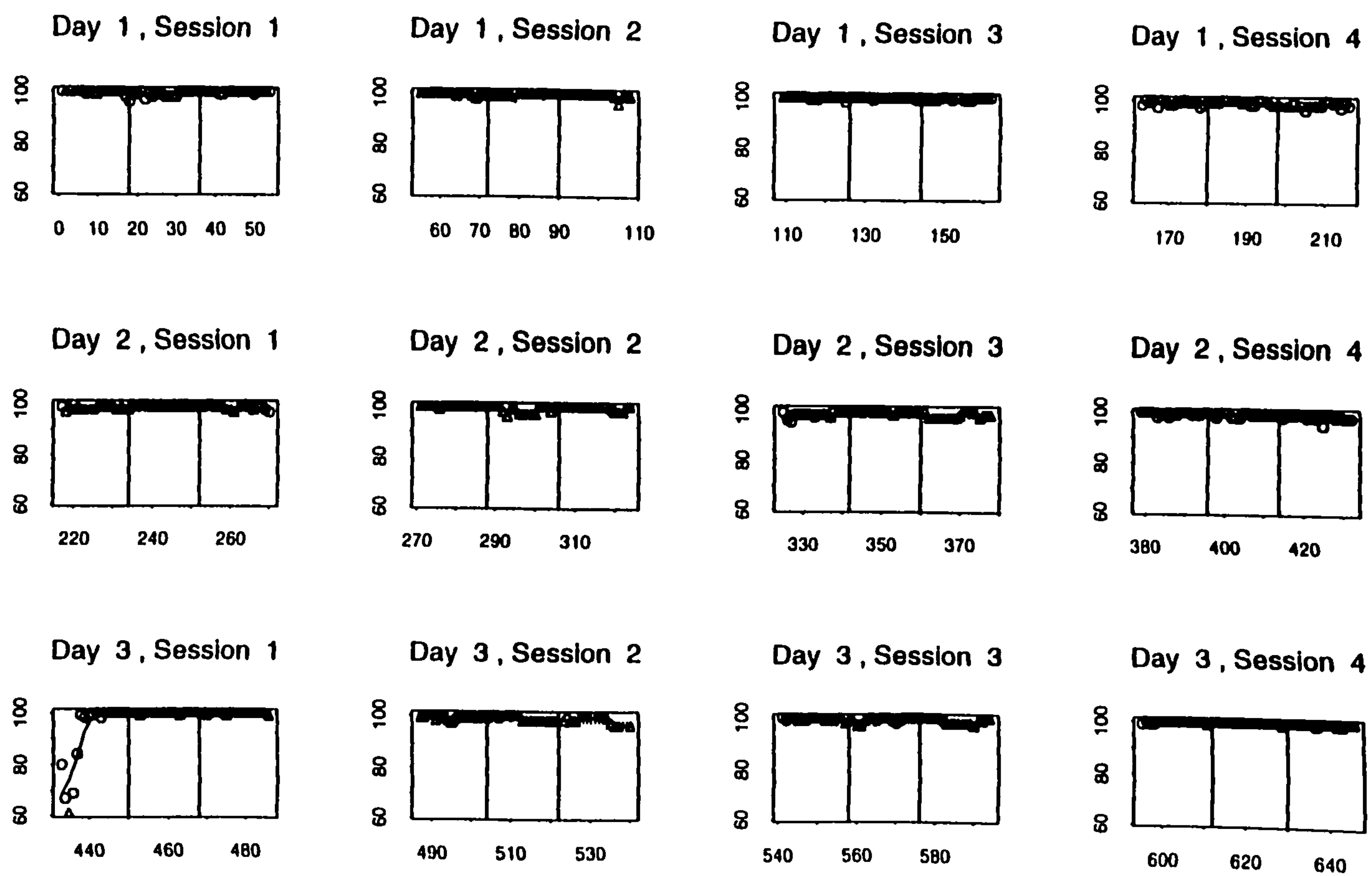


Subject 4. Oxygen Saturation by Segment for All Sessions



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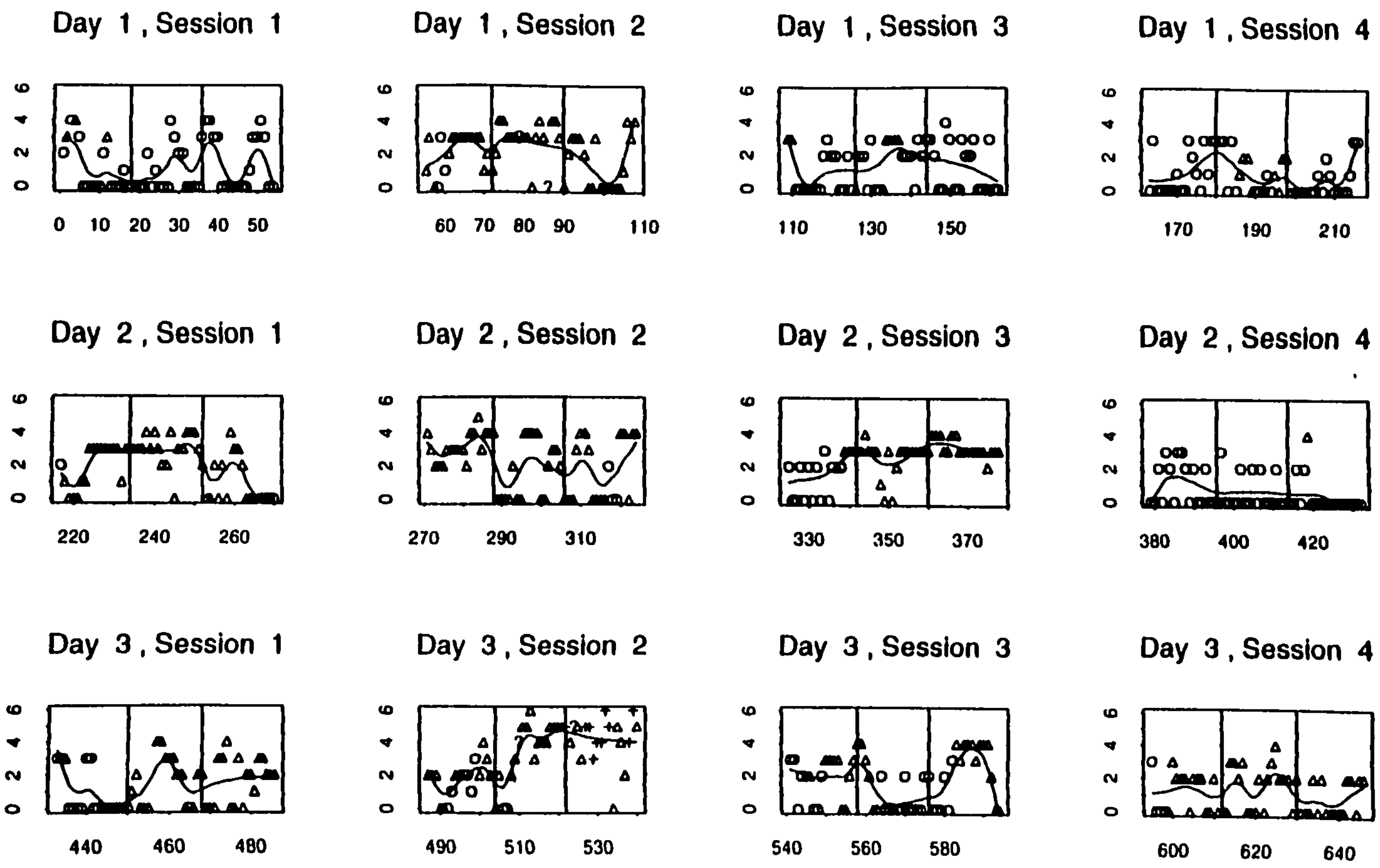

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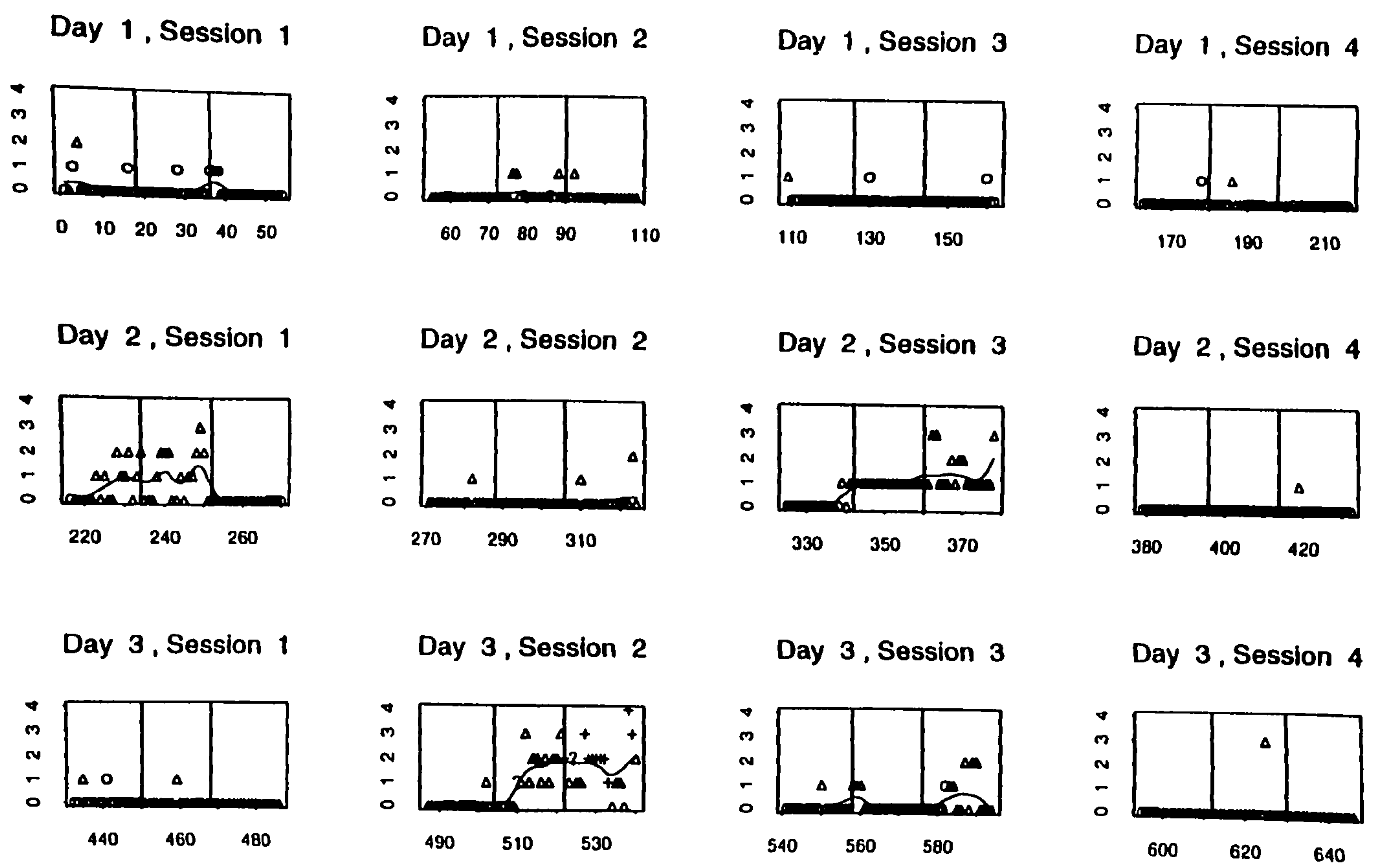

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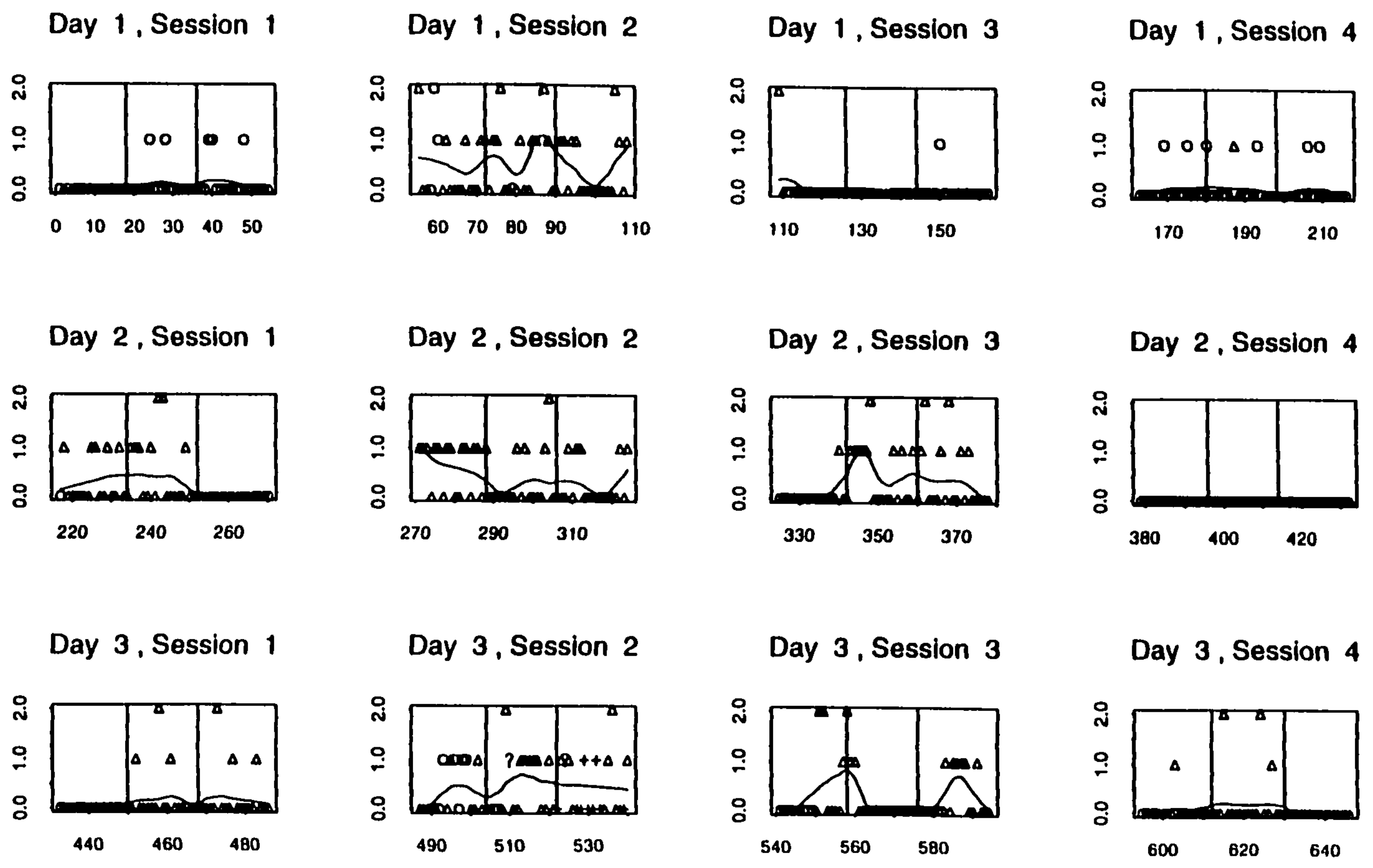

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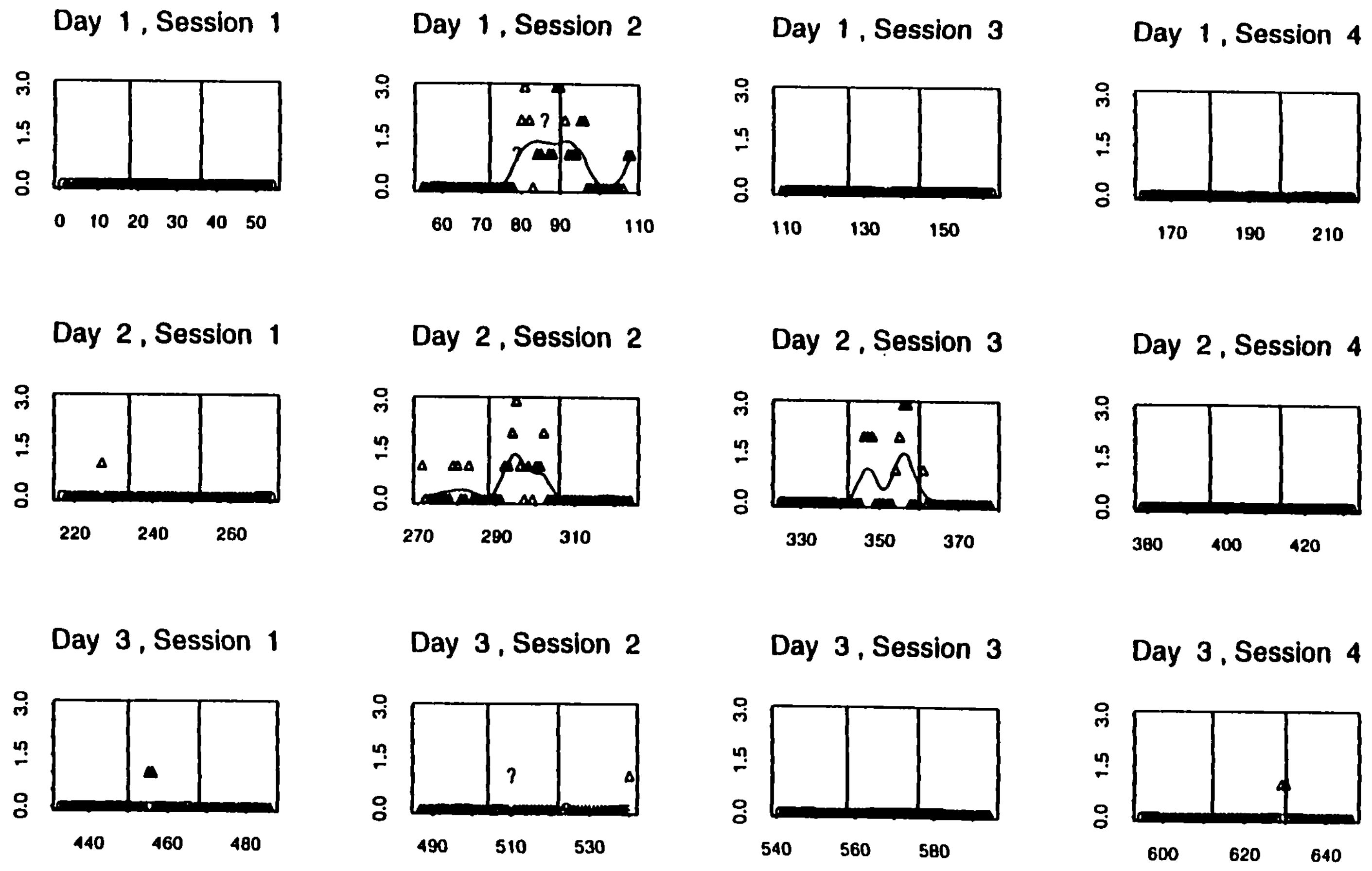
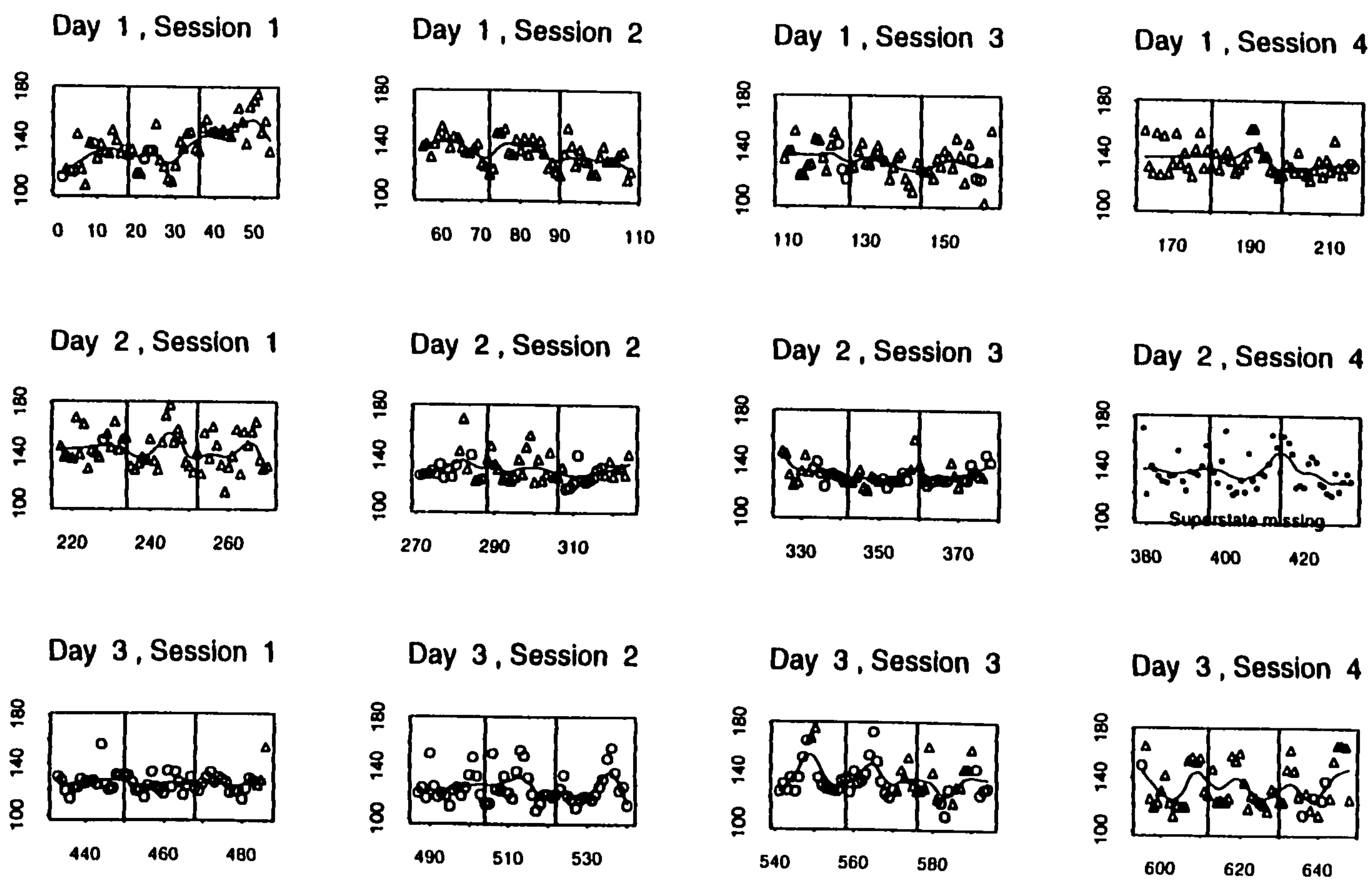


Subject 5. Heart rate by Segment for All Sessions



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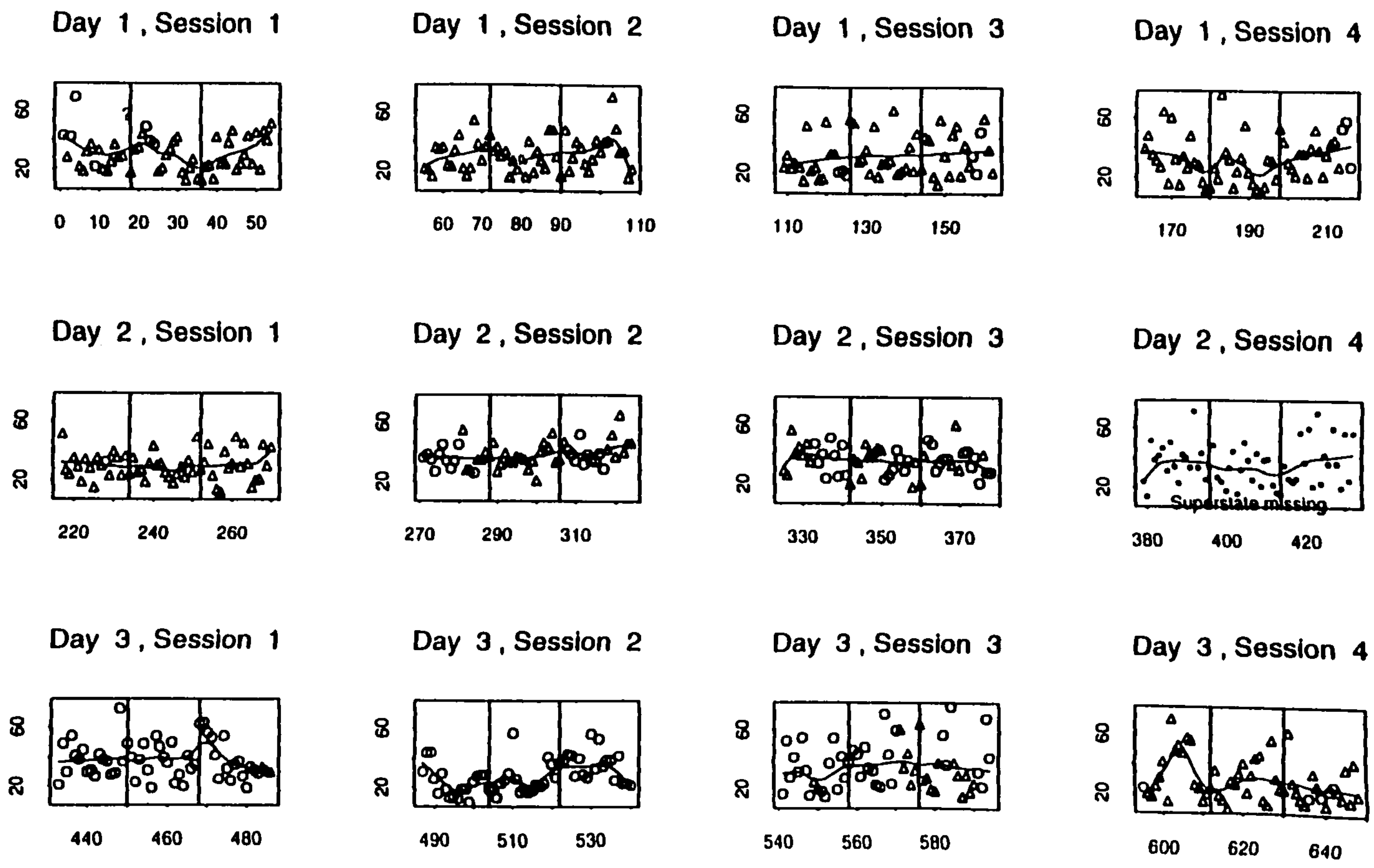
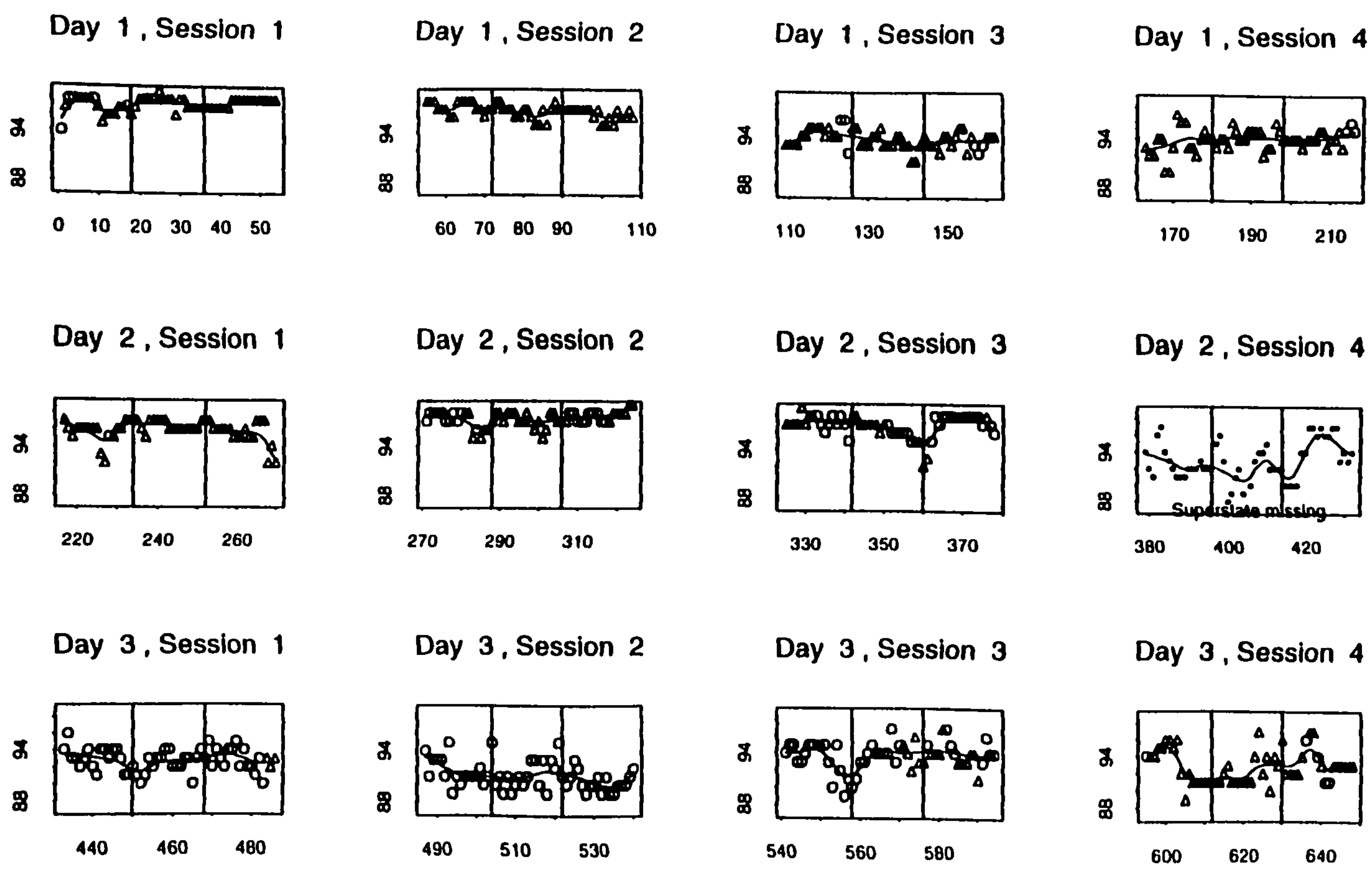


Subject 5. Oxygen Saturation by Segment for All Sessions



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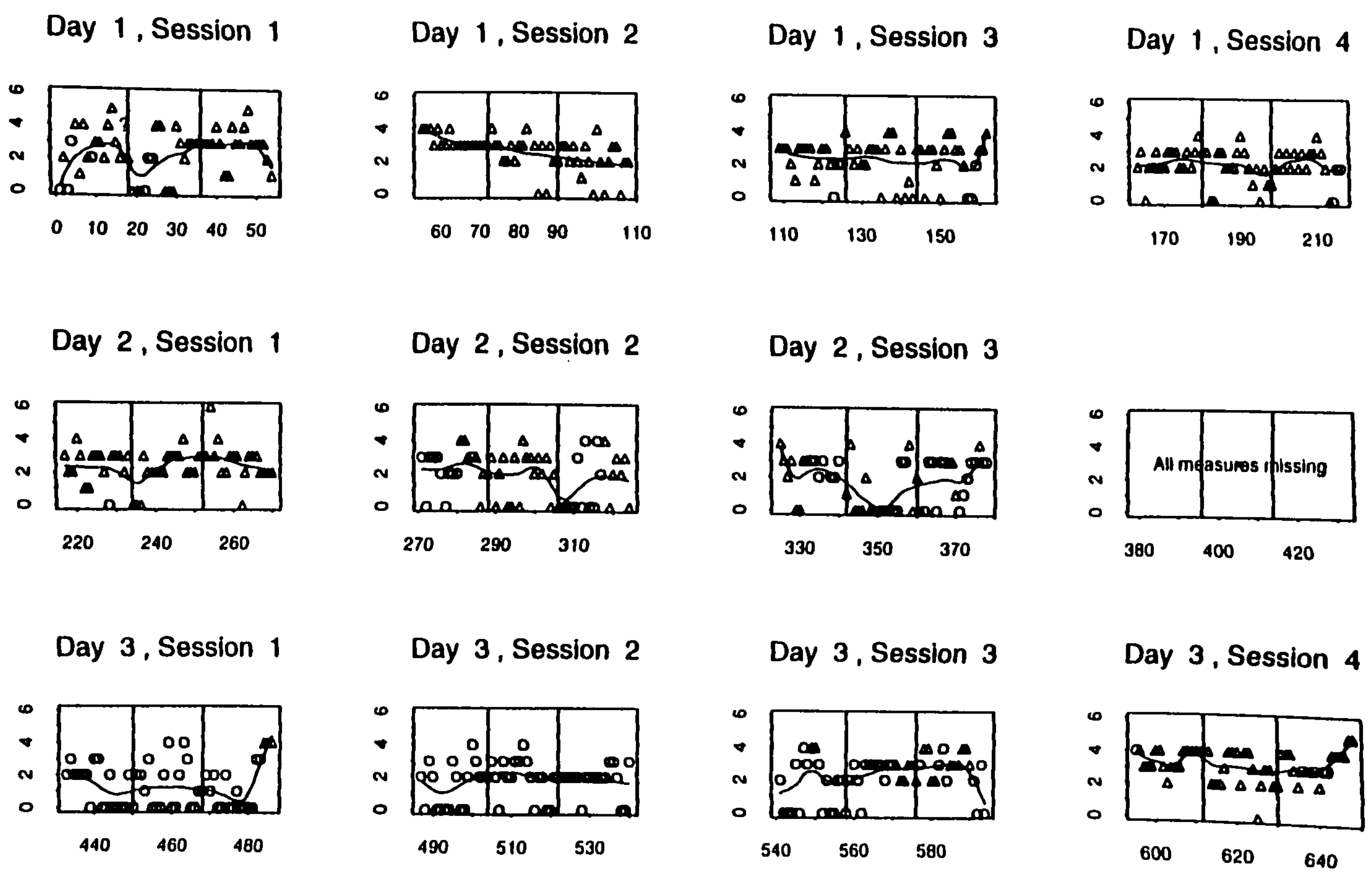

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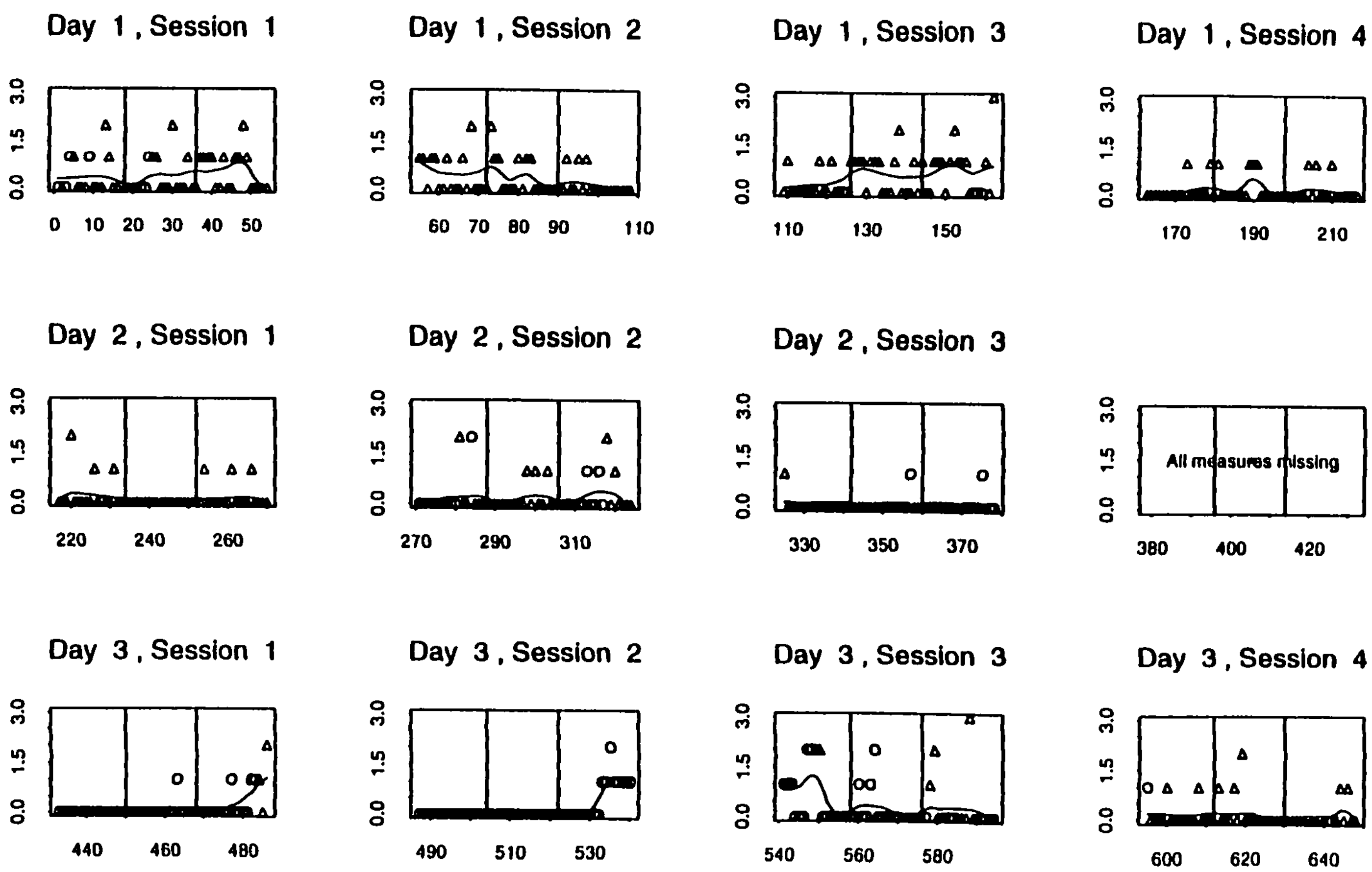
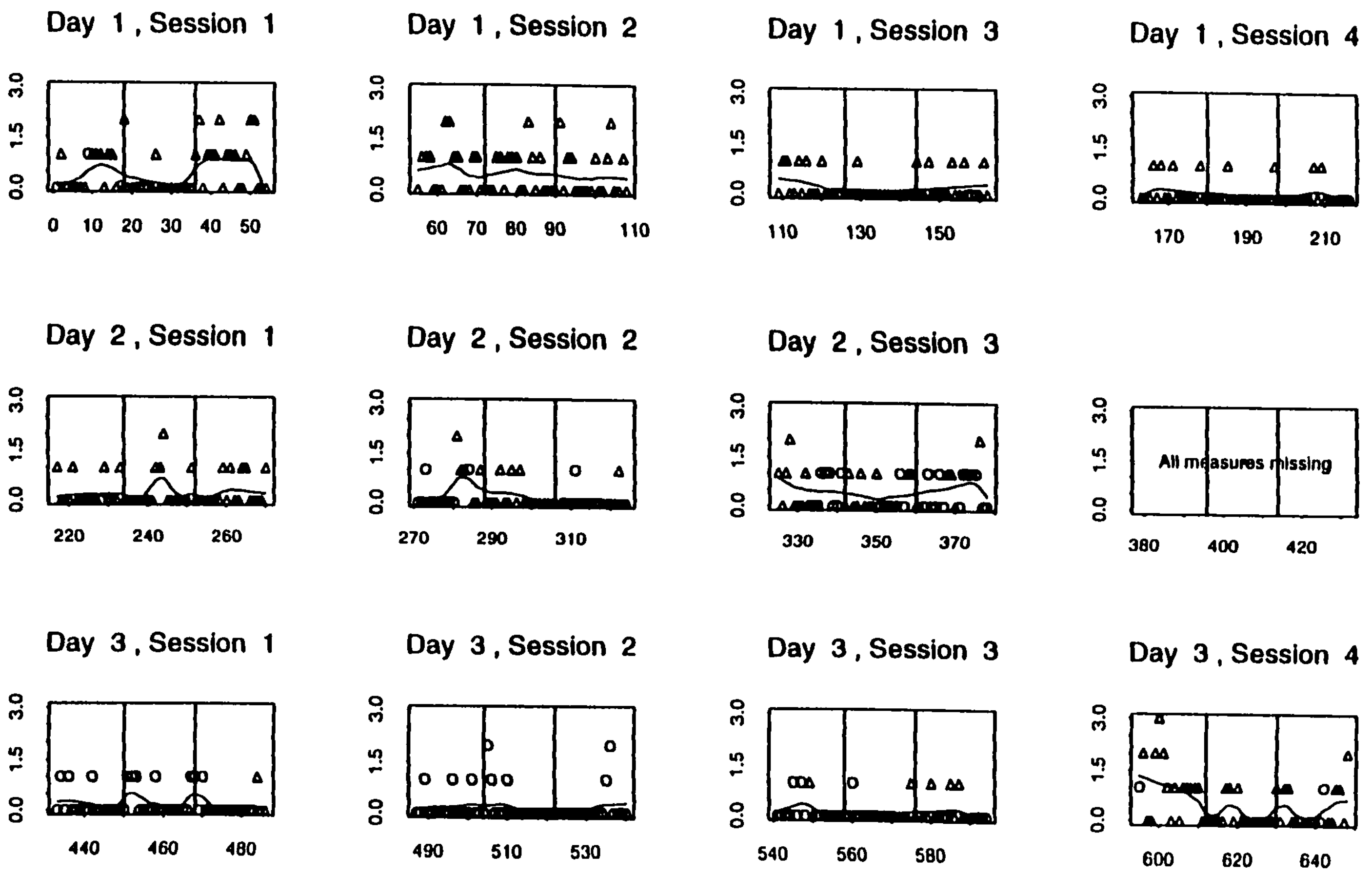
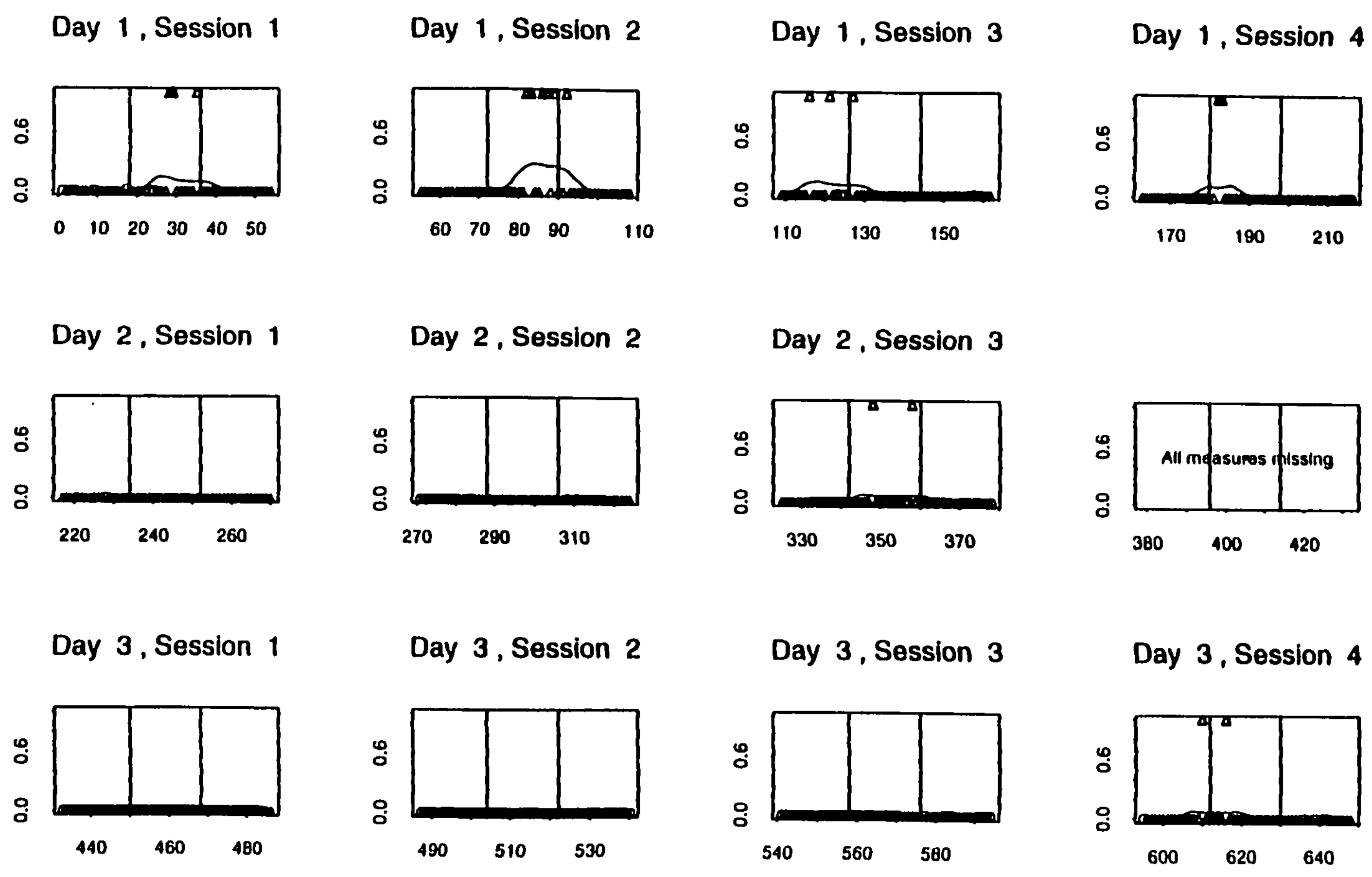


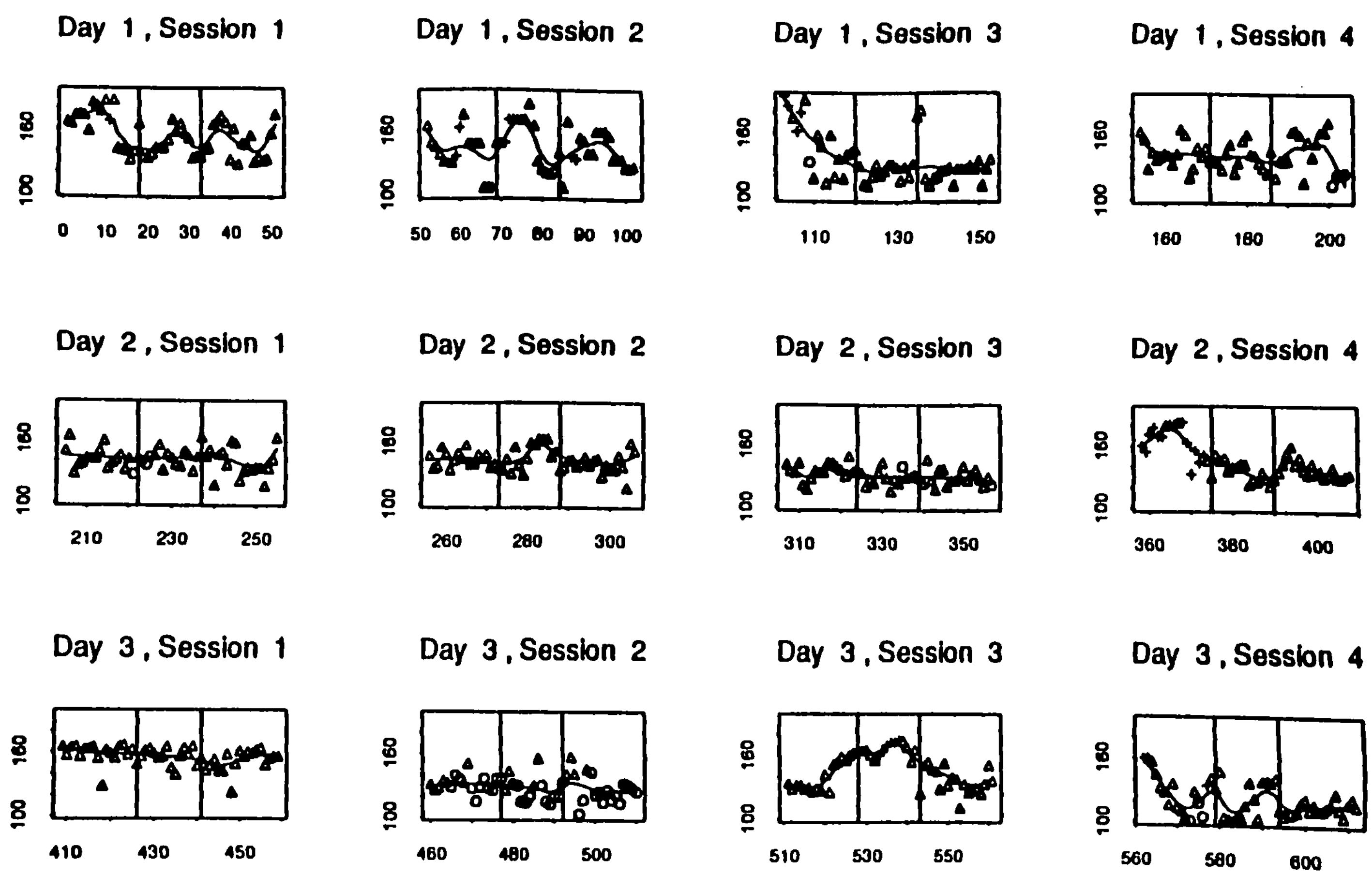
Subject 5. Stability Score by Segment for All Sessions



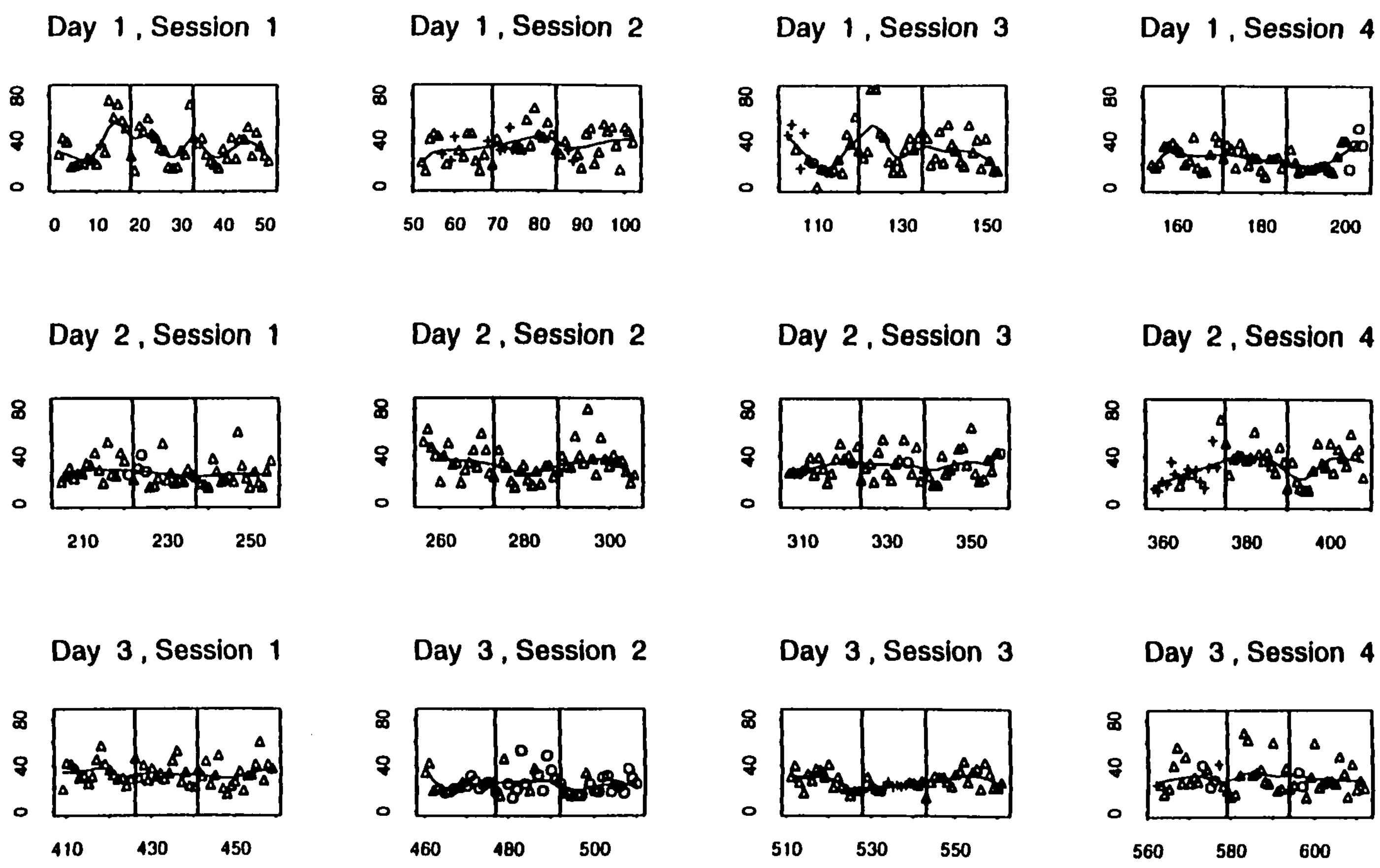
Subject 5. Attend Score by Segment For All Sessions



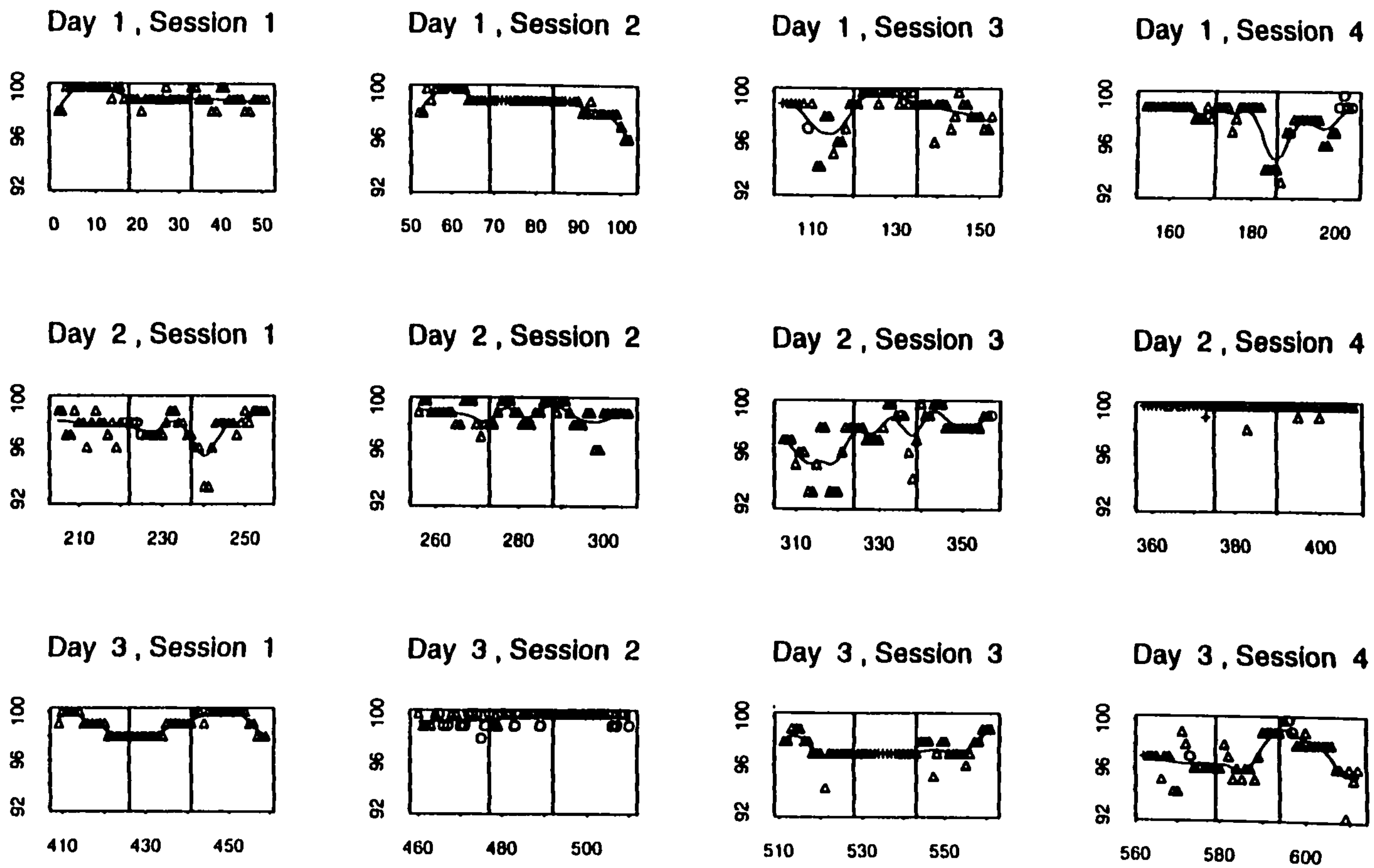
Subject 6. Heart Rate by Segment for All Sessions



Subject 6. Respiratory Rate by Segment for All Sessions



Subject 6. Oxygen Saturation by Segment for All Sessions



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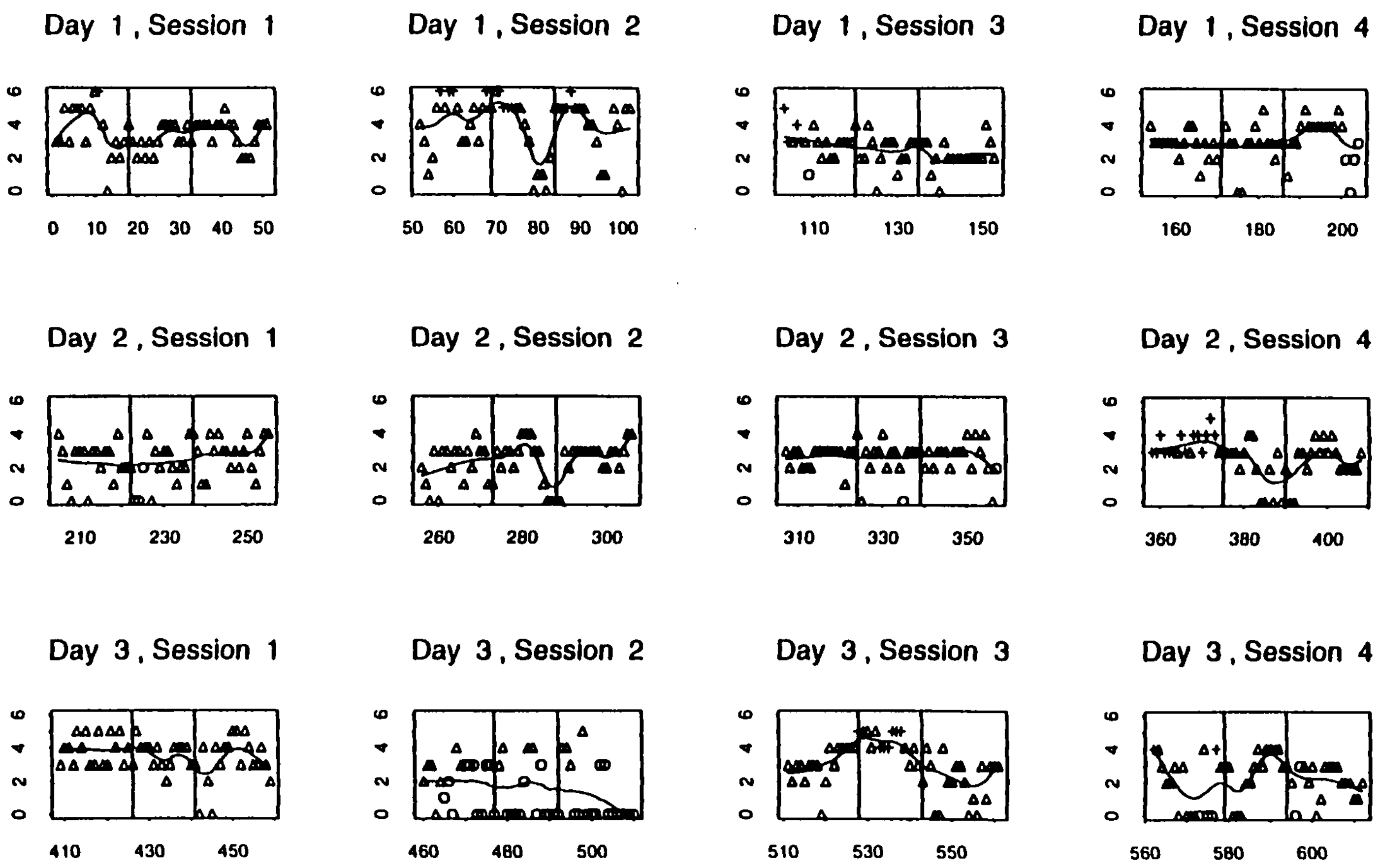

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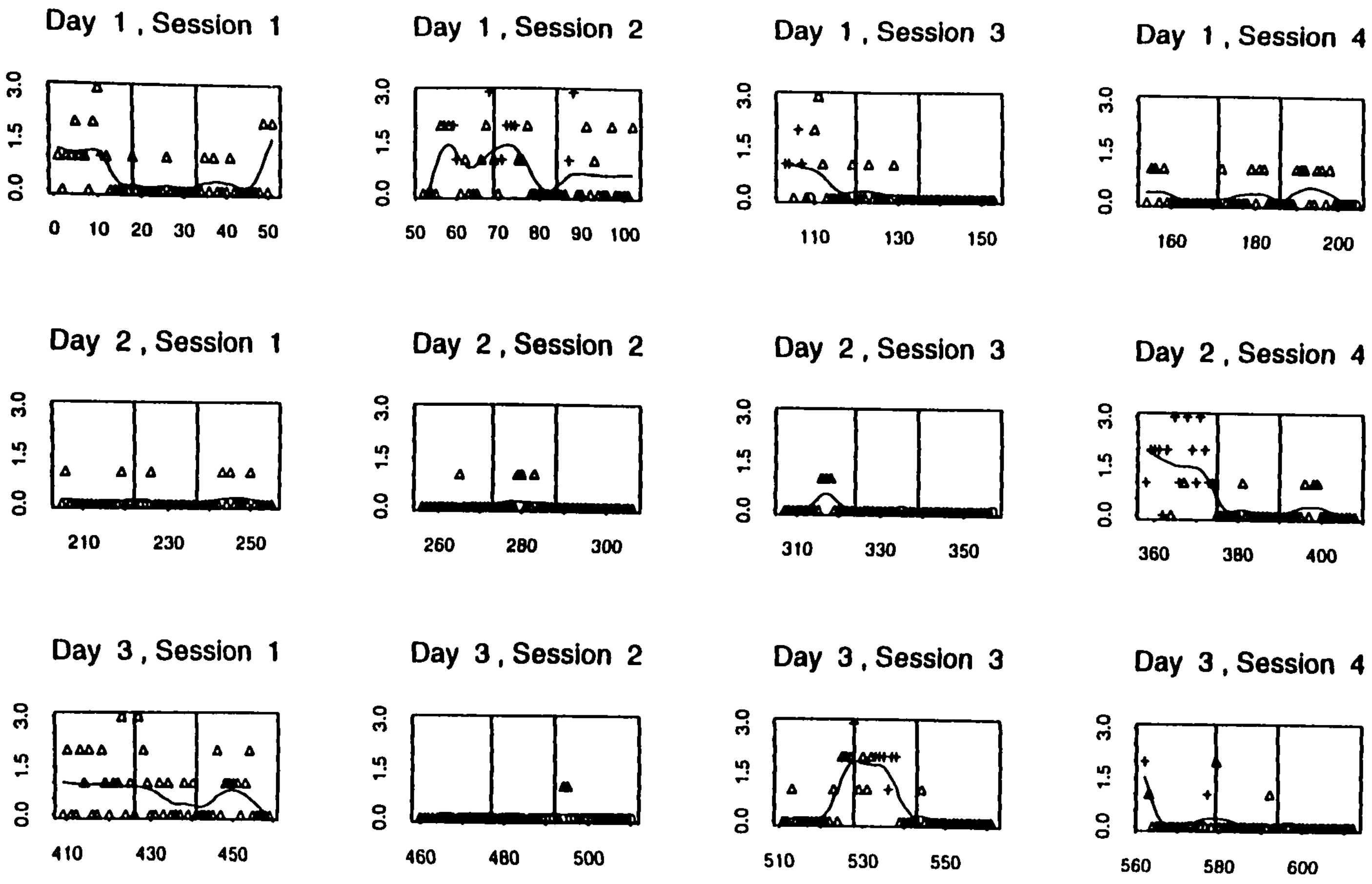

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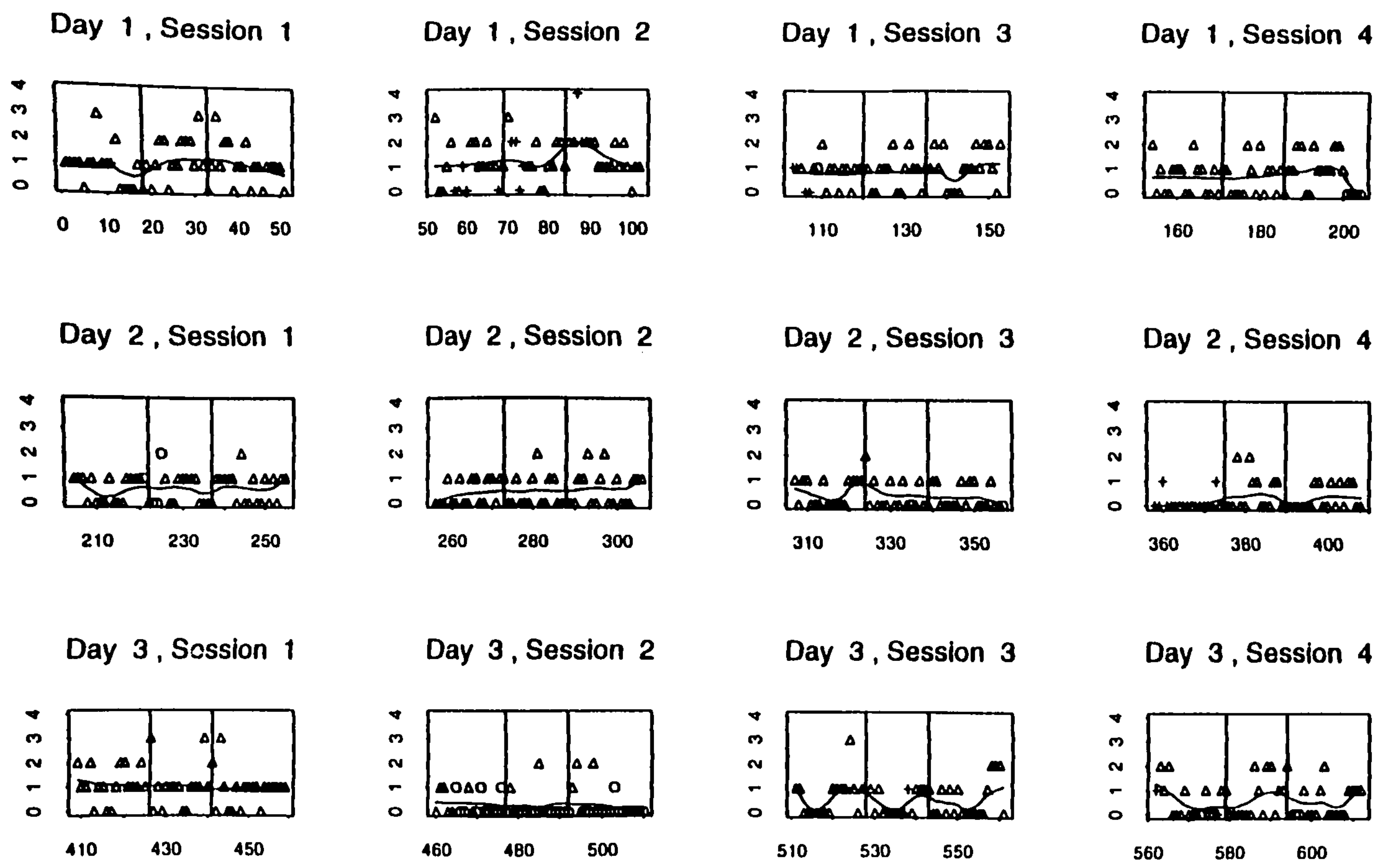

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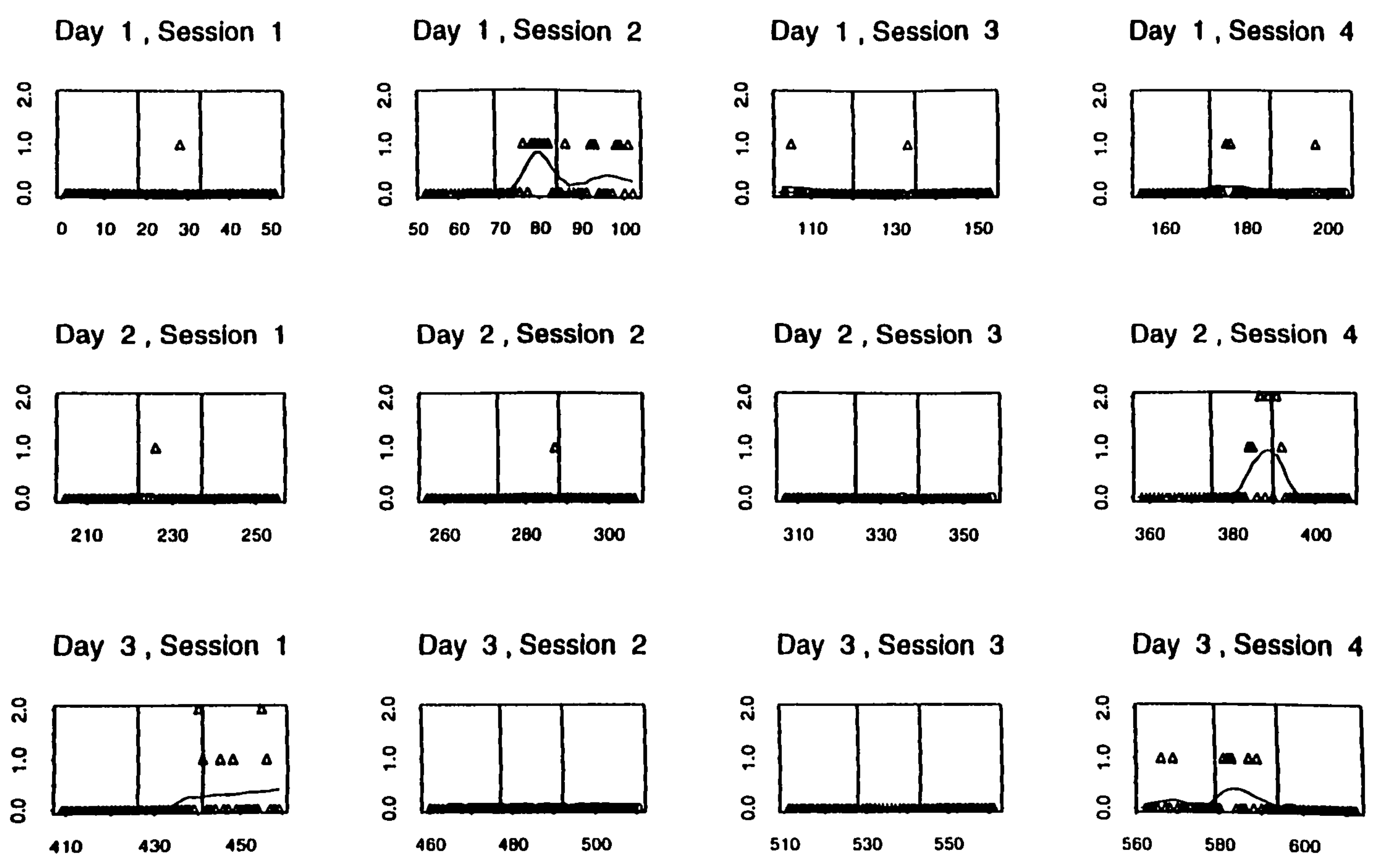

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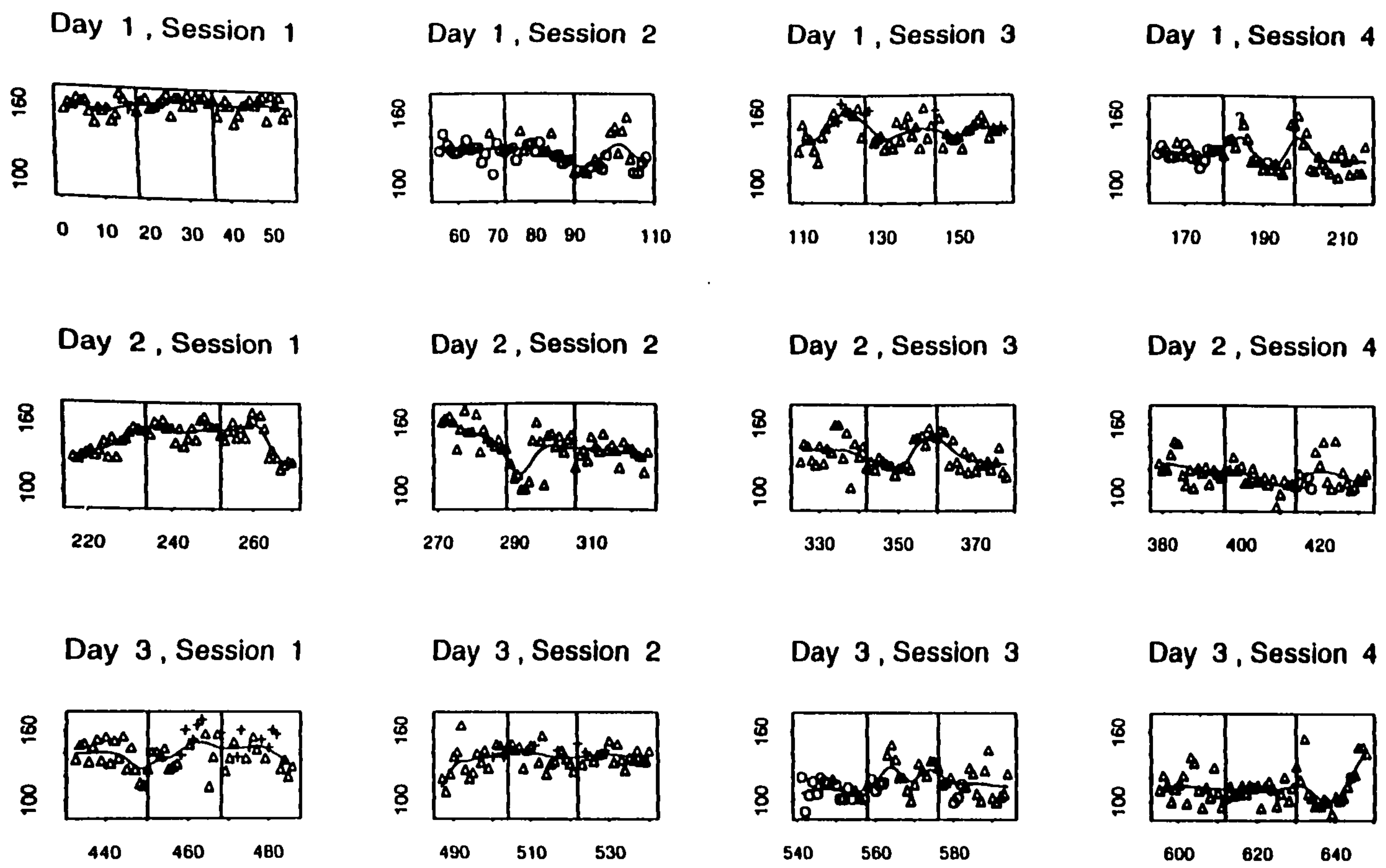

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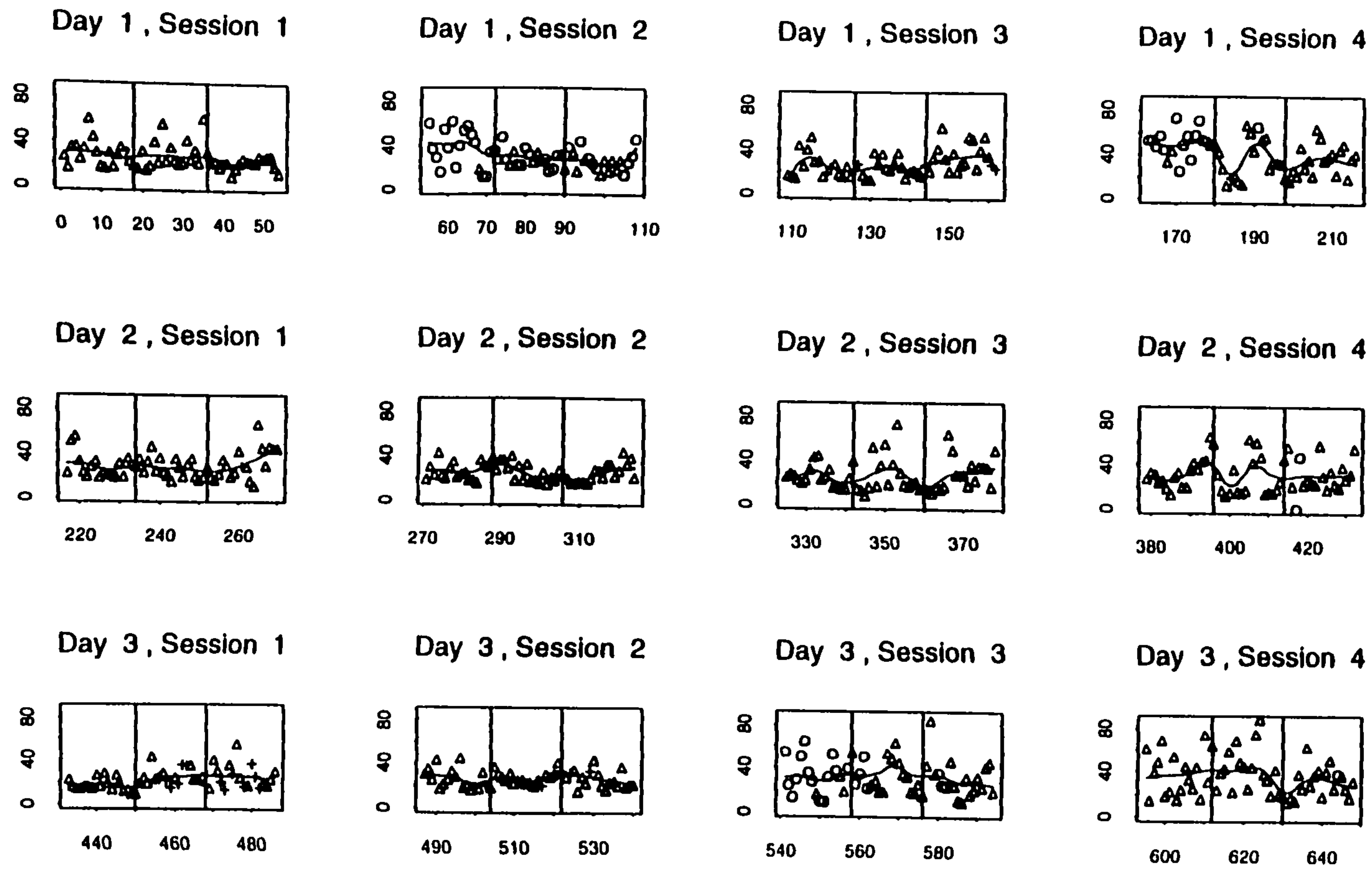

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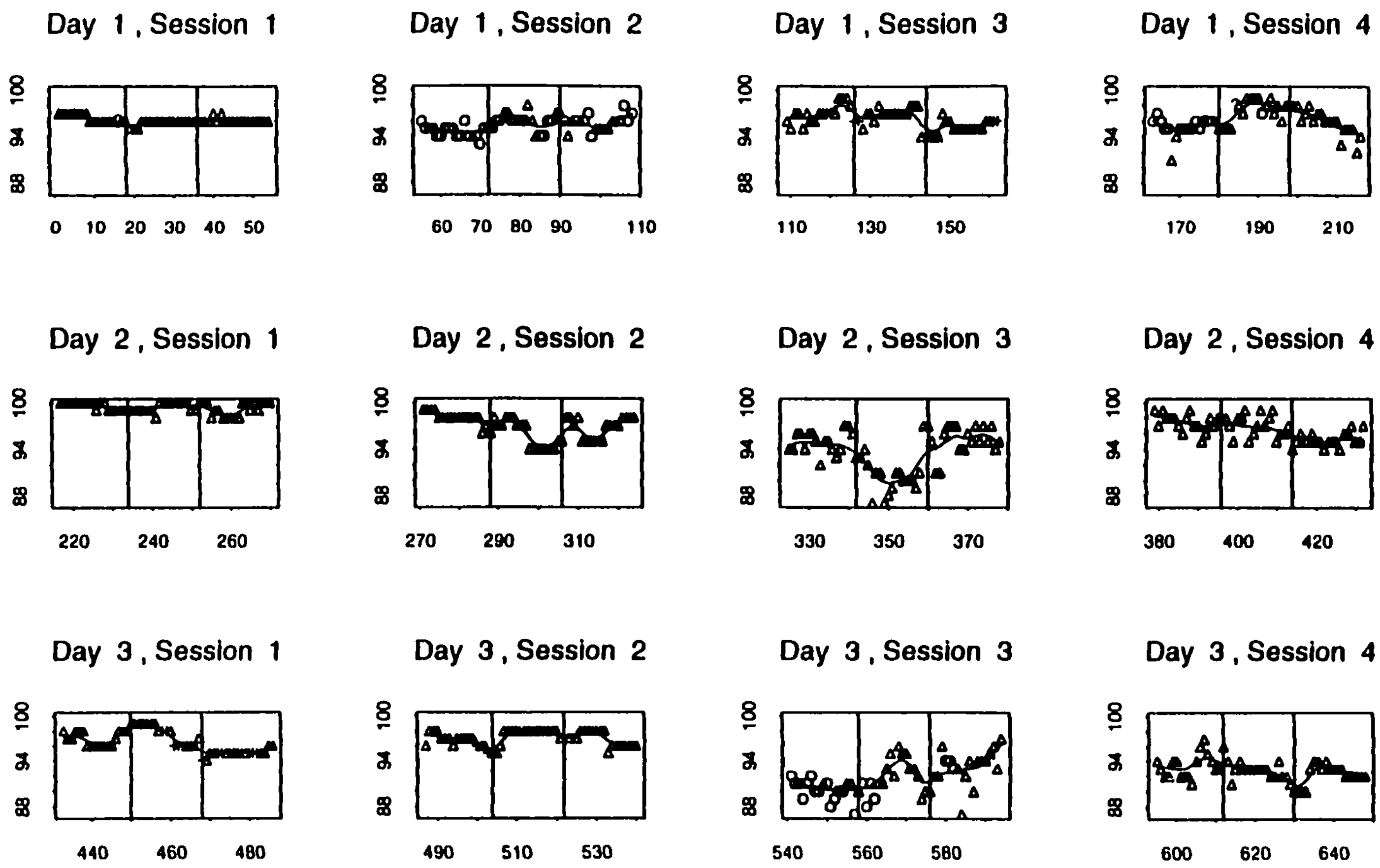

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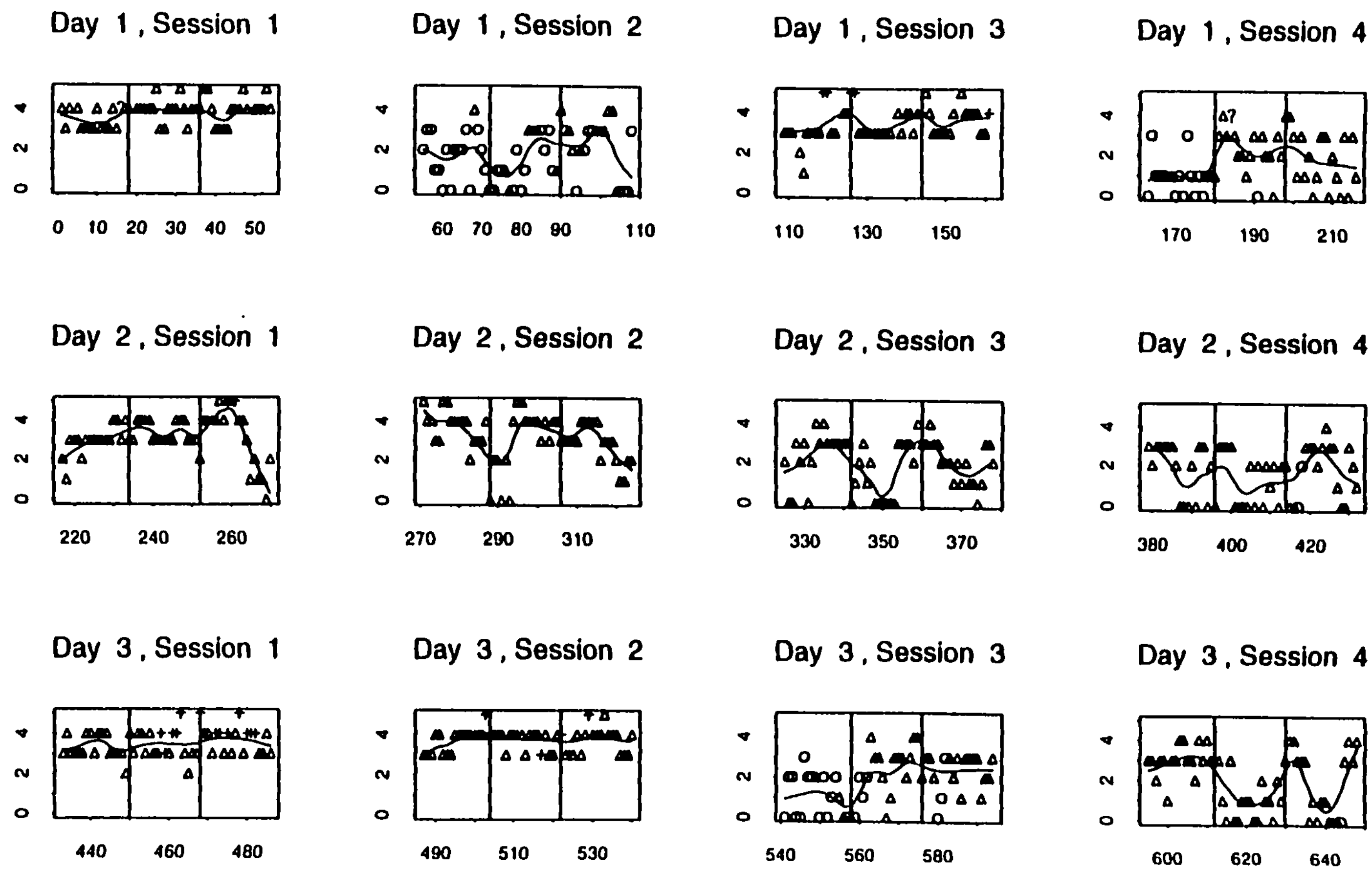

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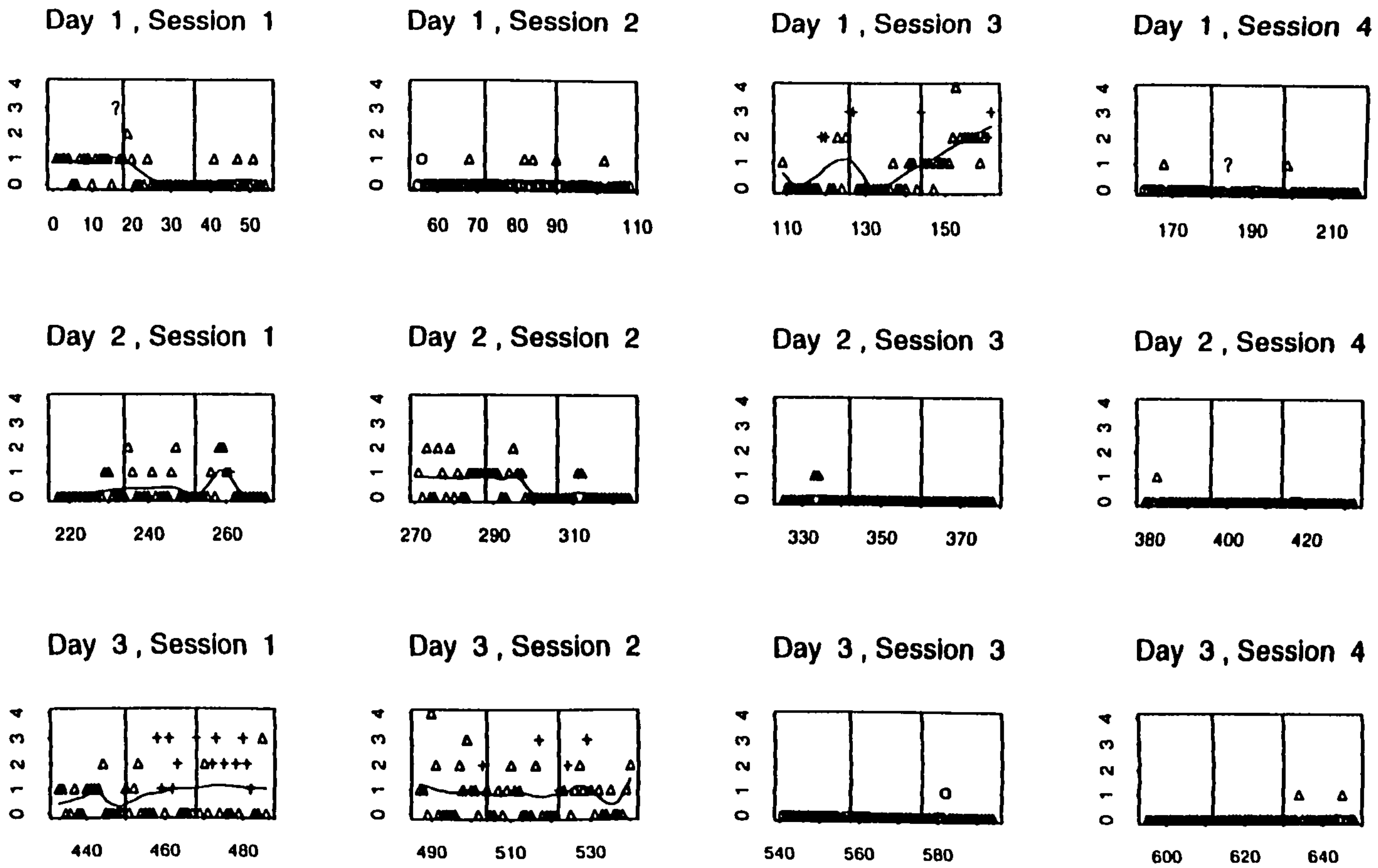

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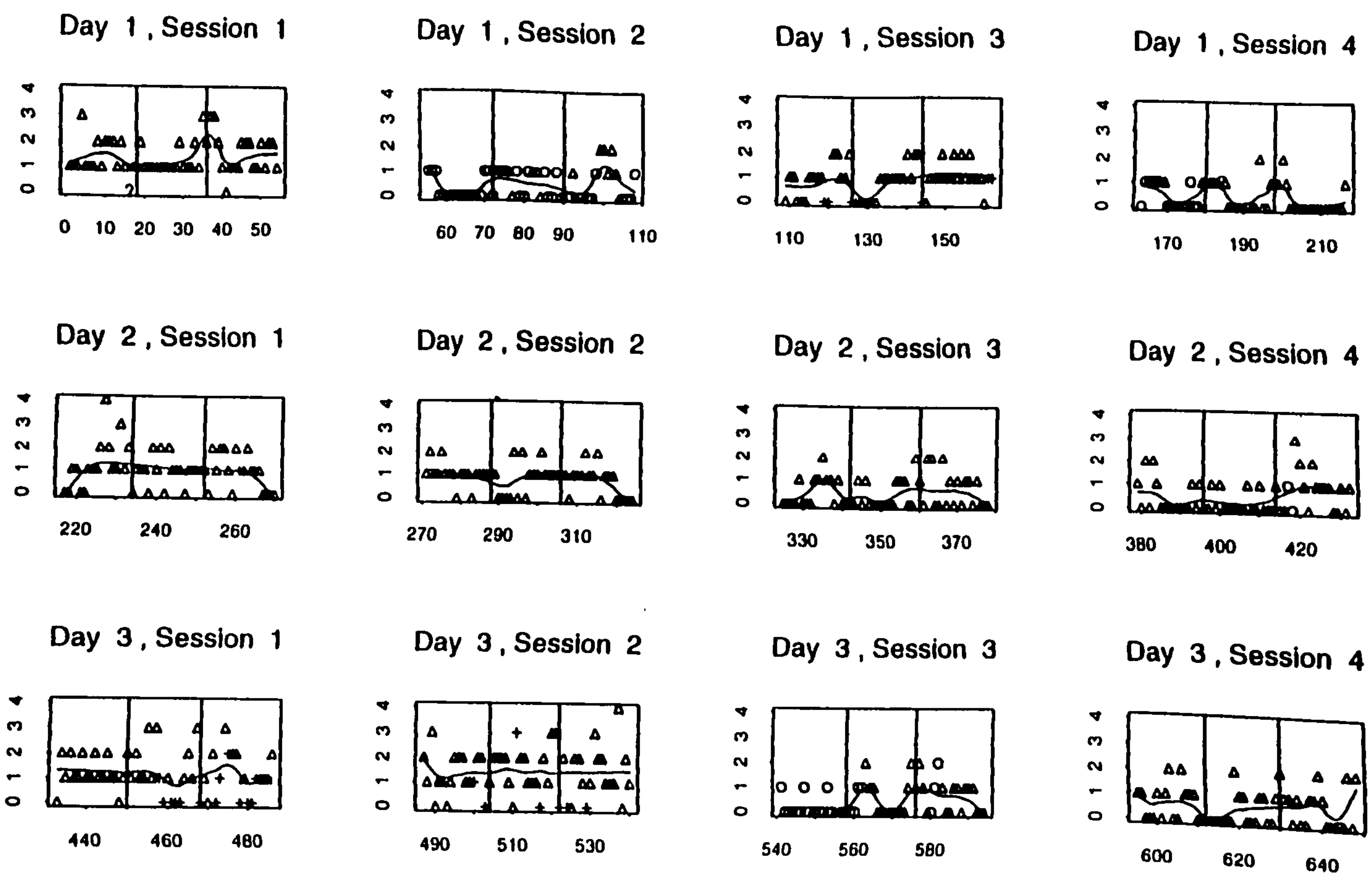

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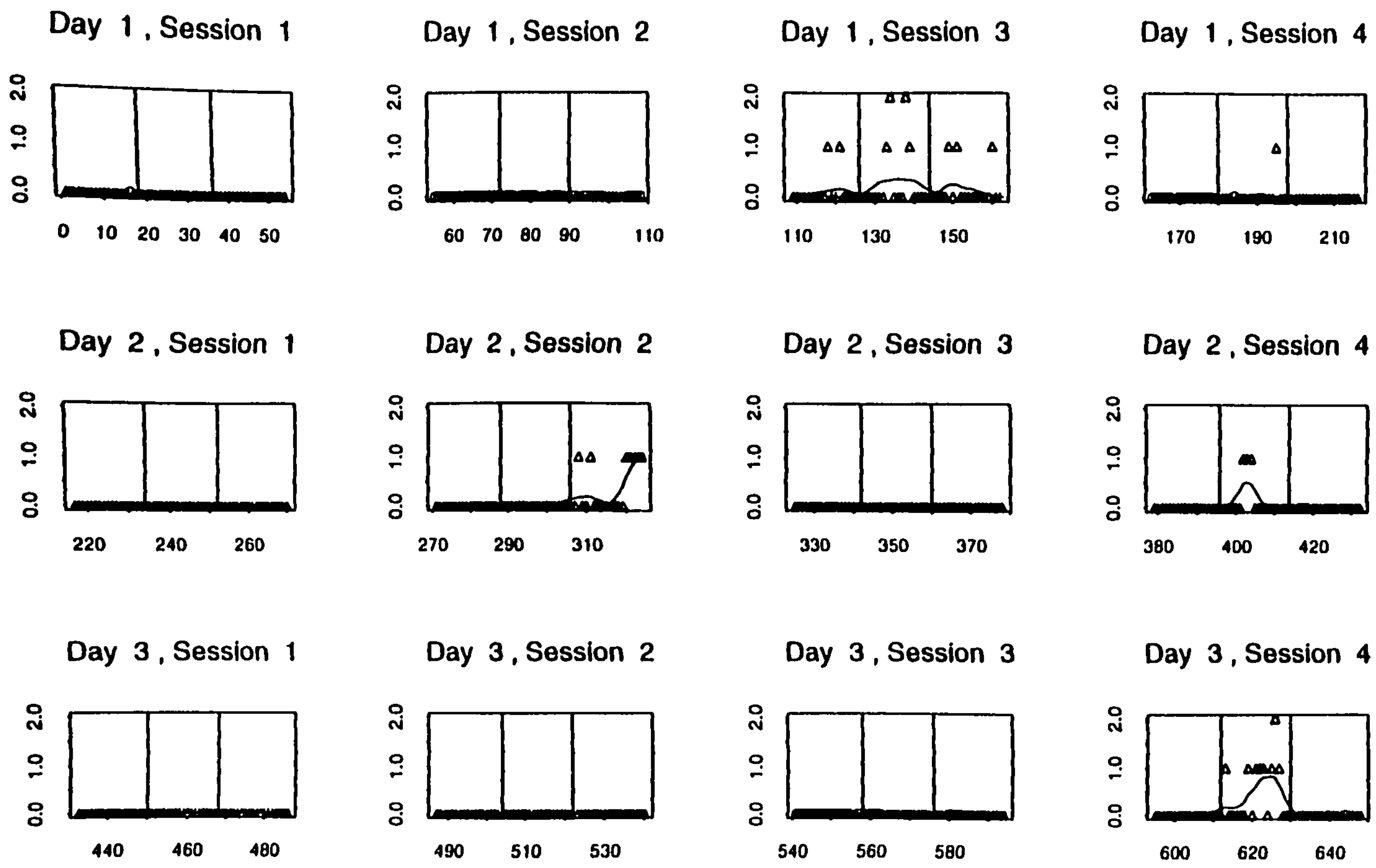

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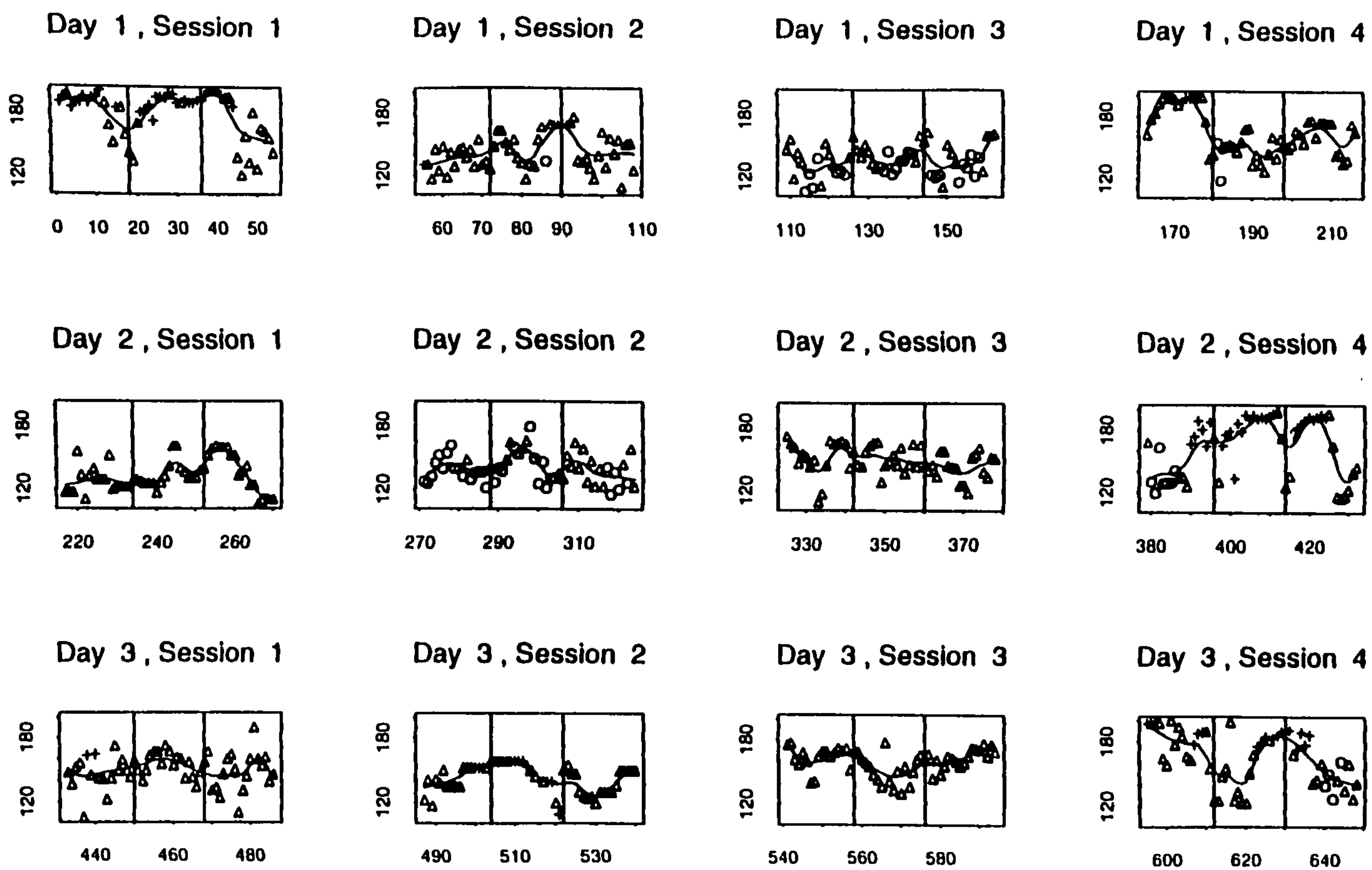

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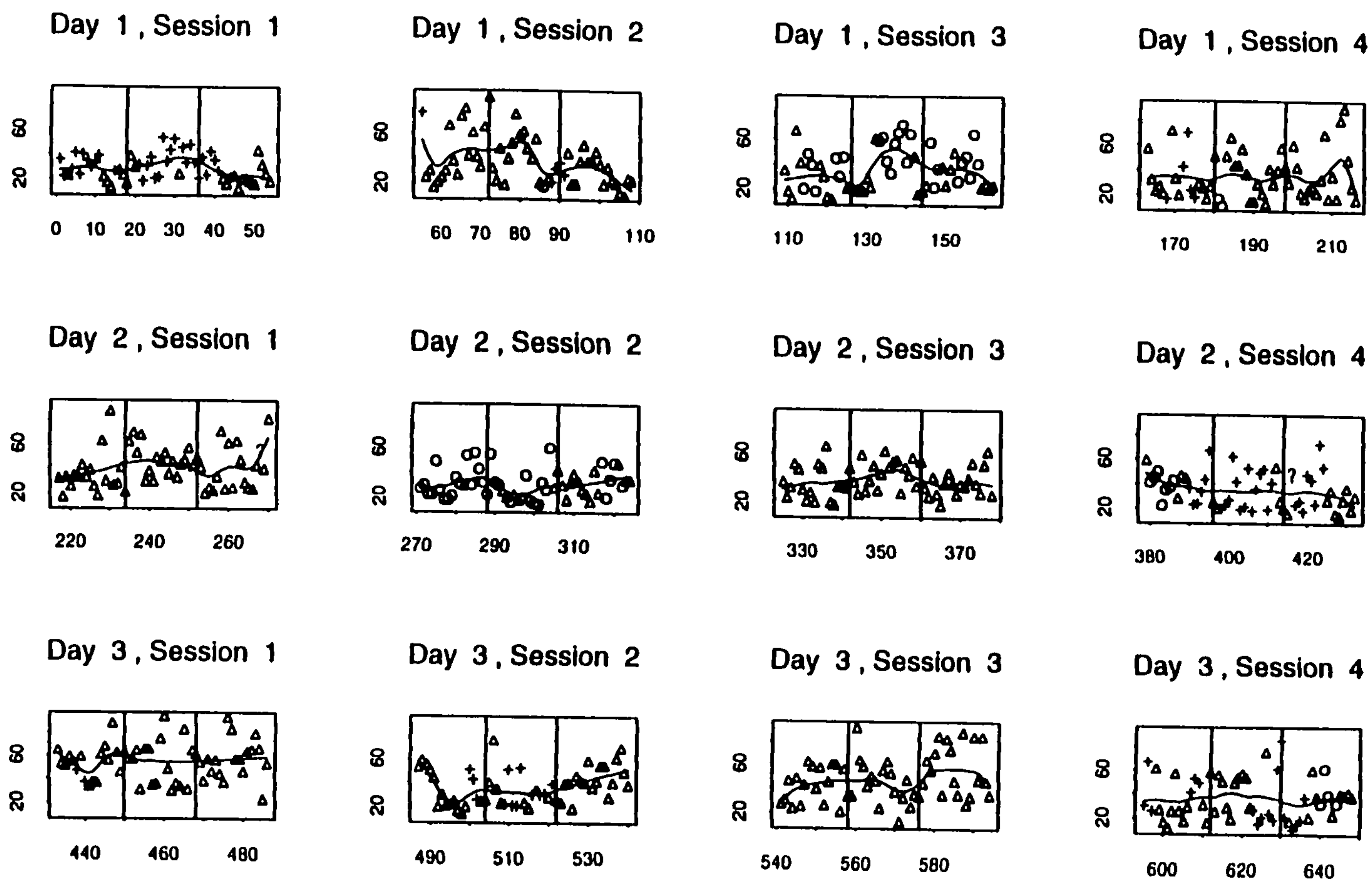

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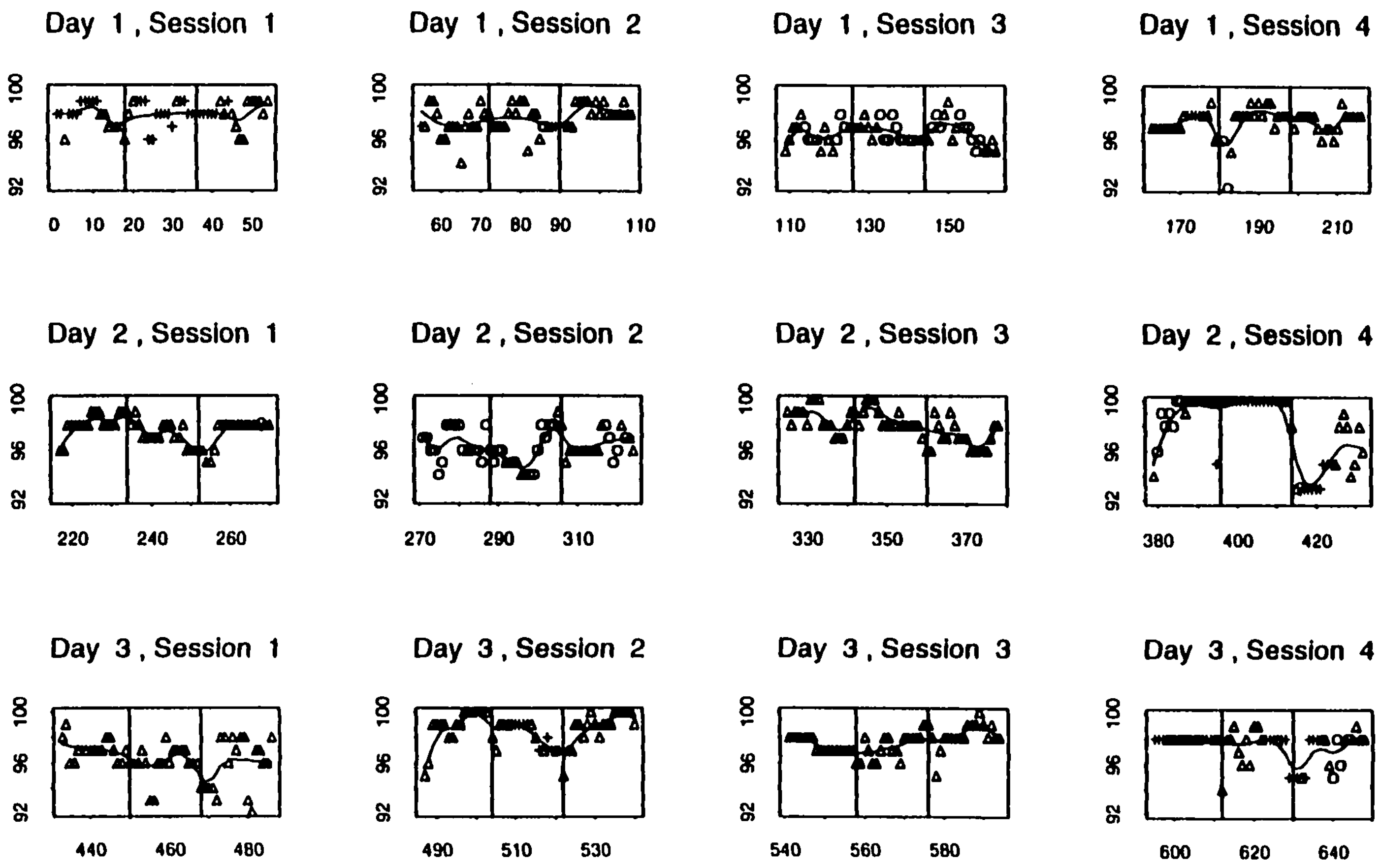

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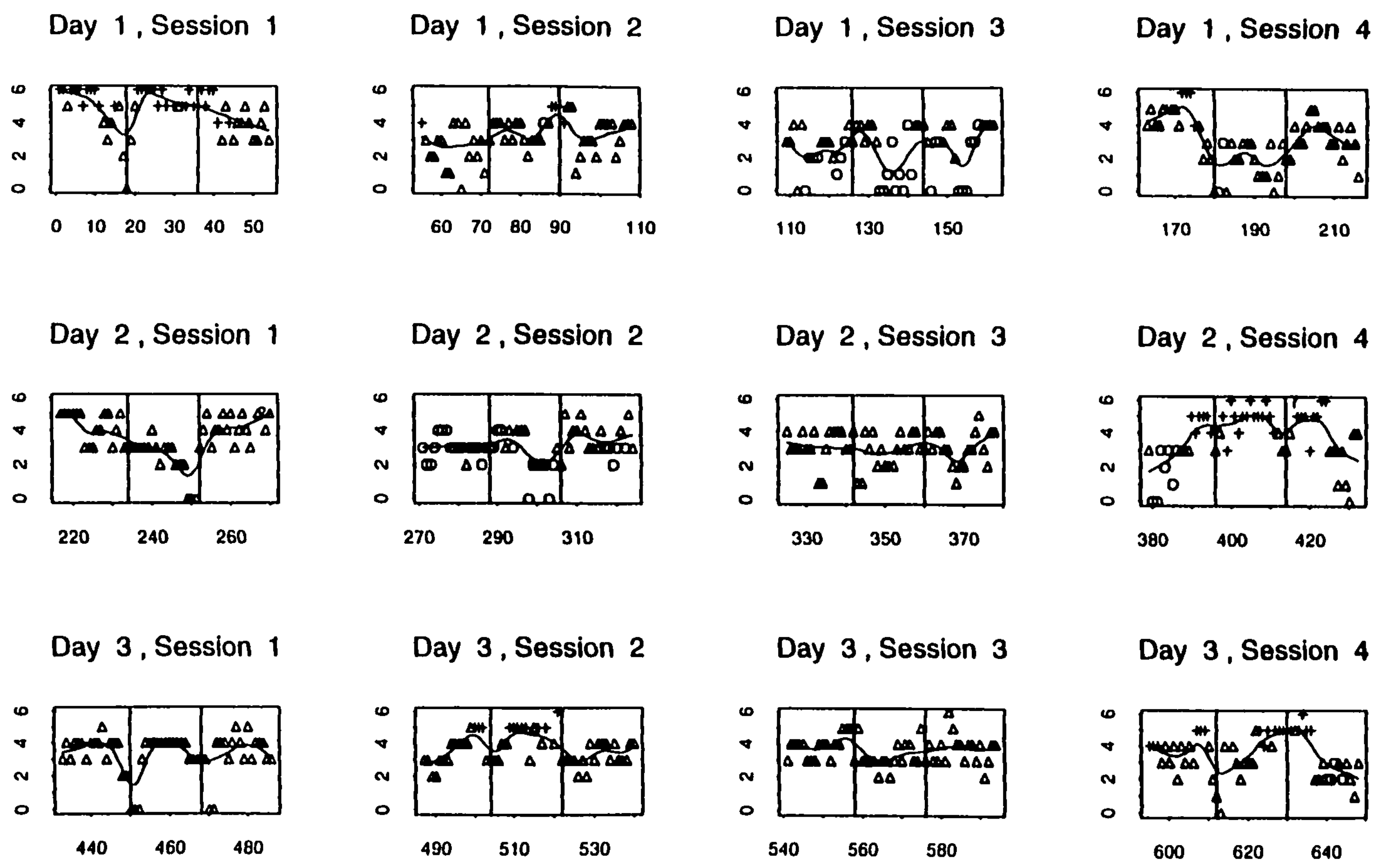

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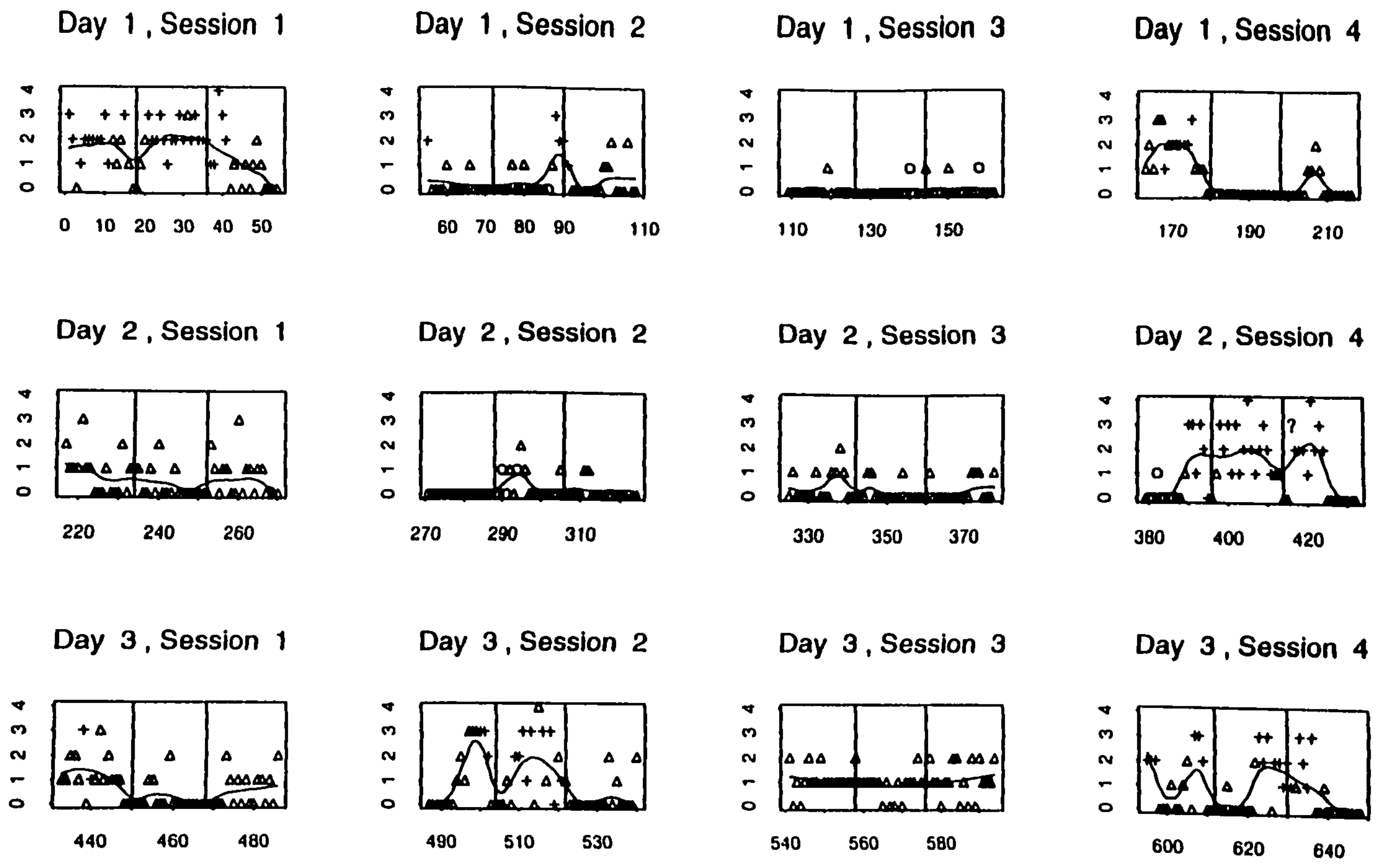

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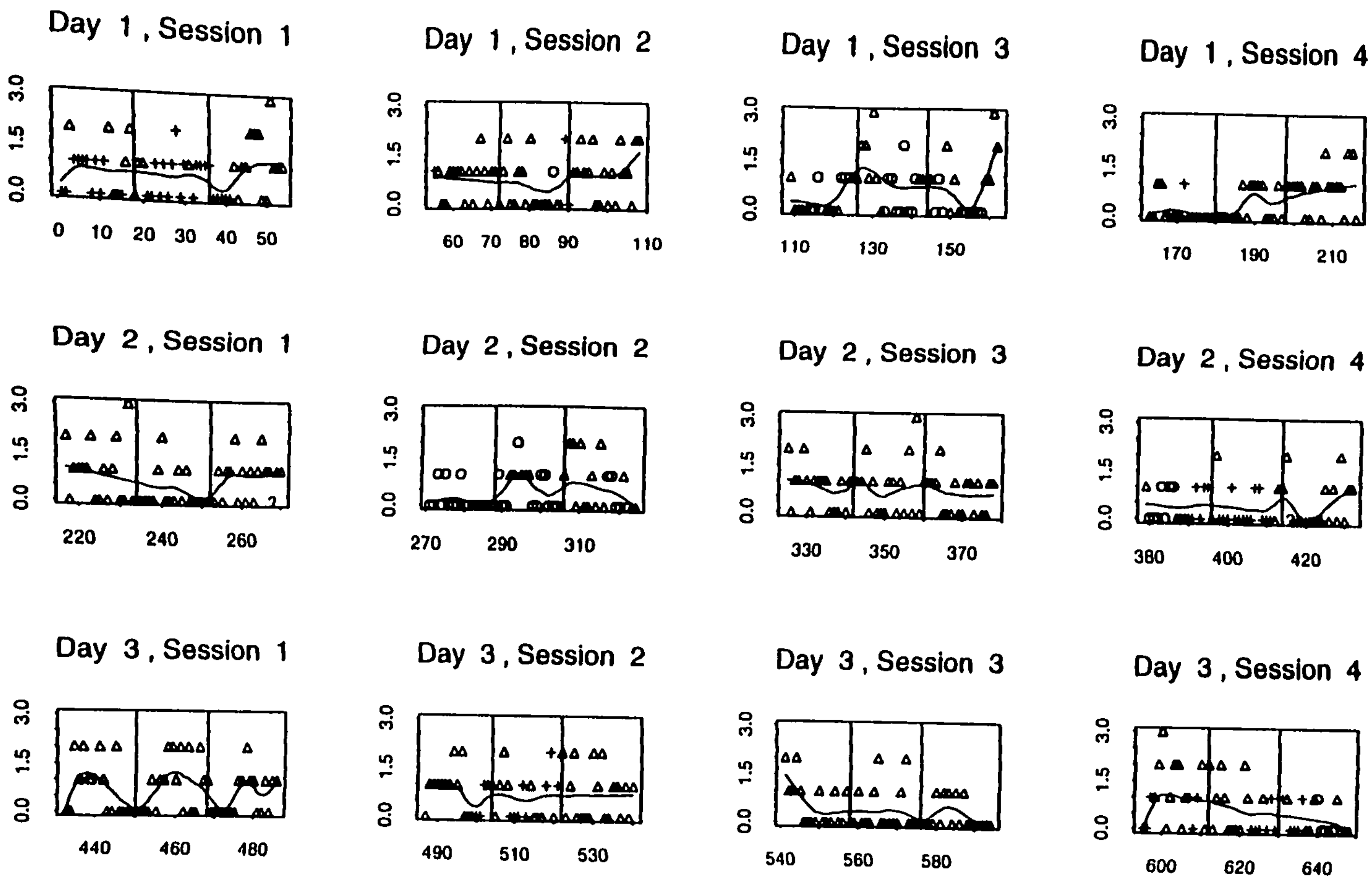

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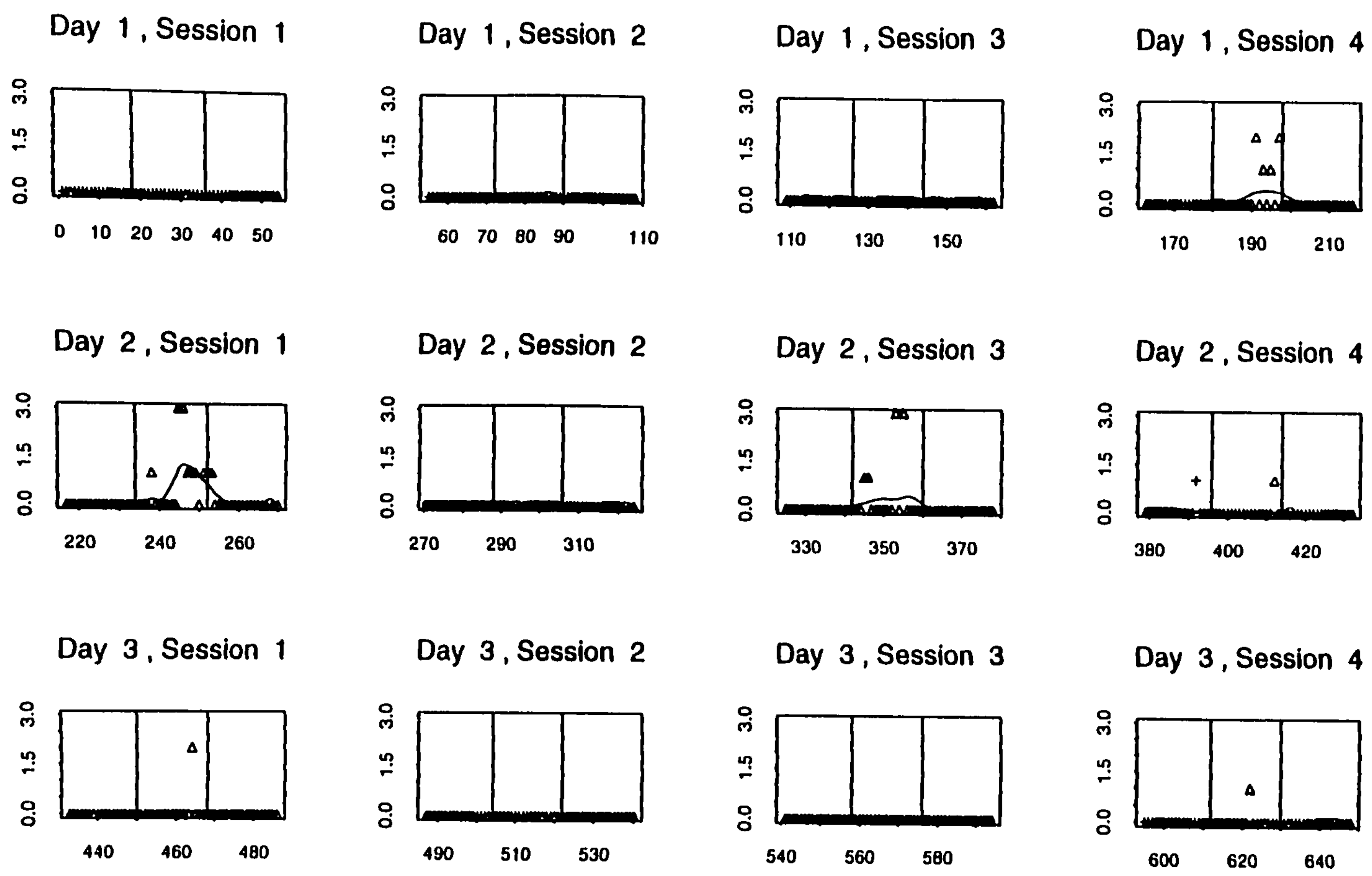

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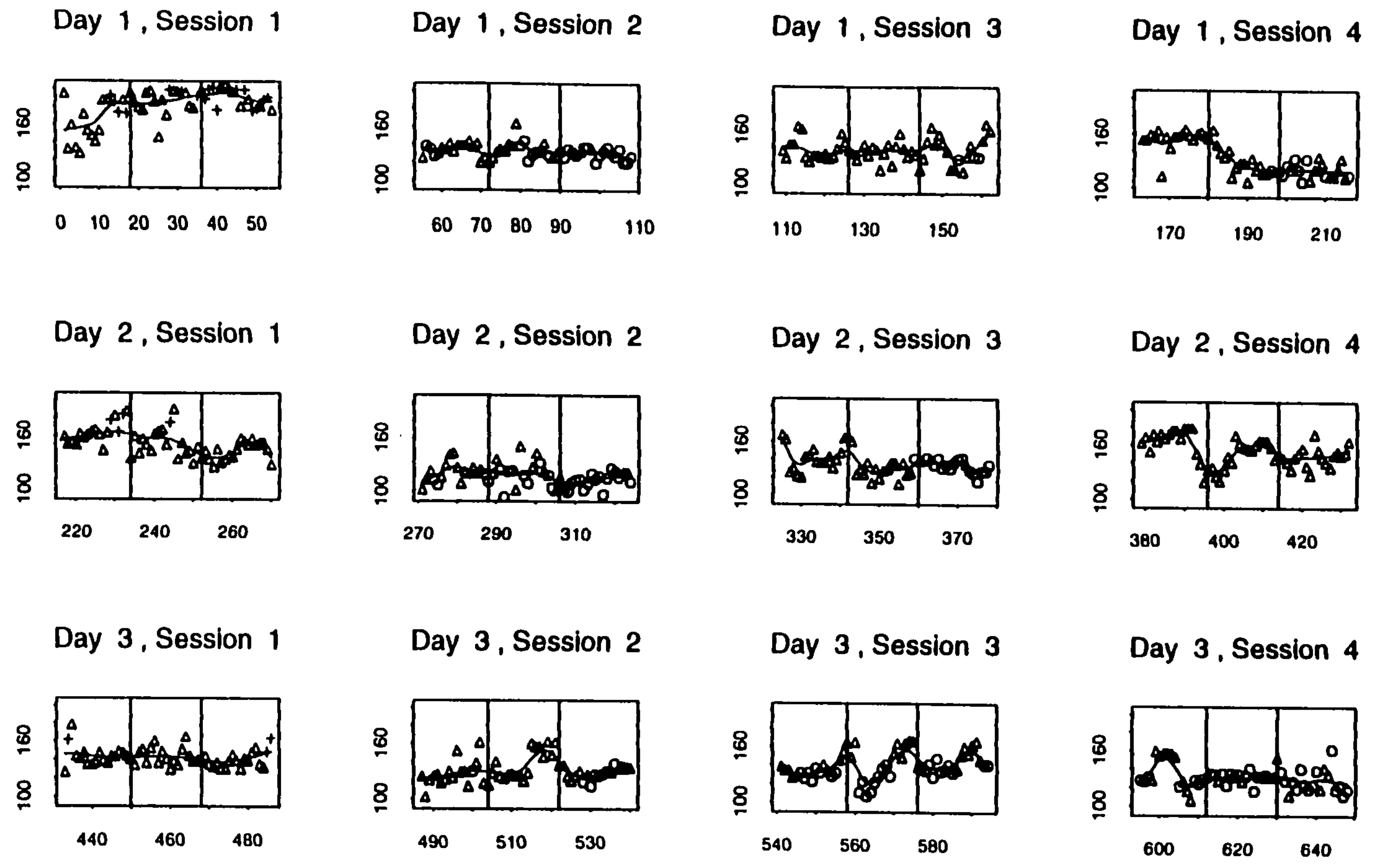

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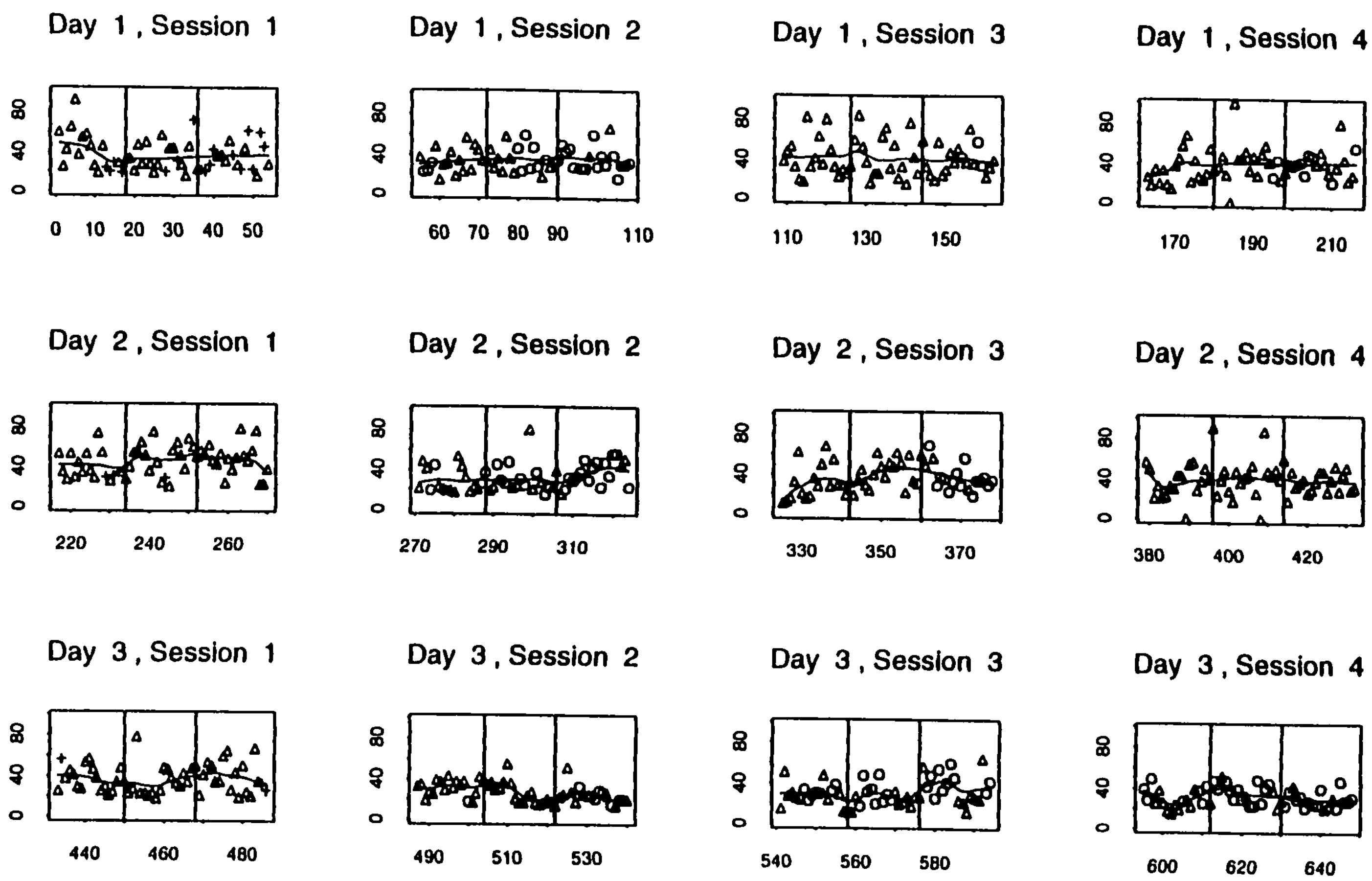

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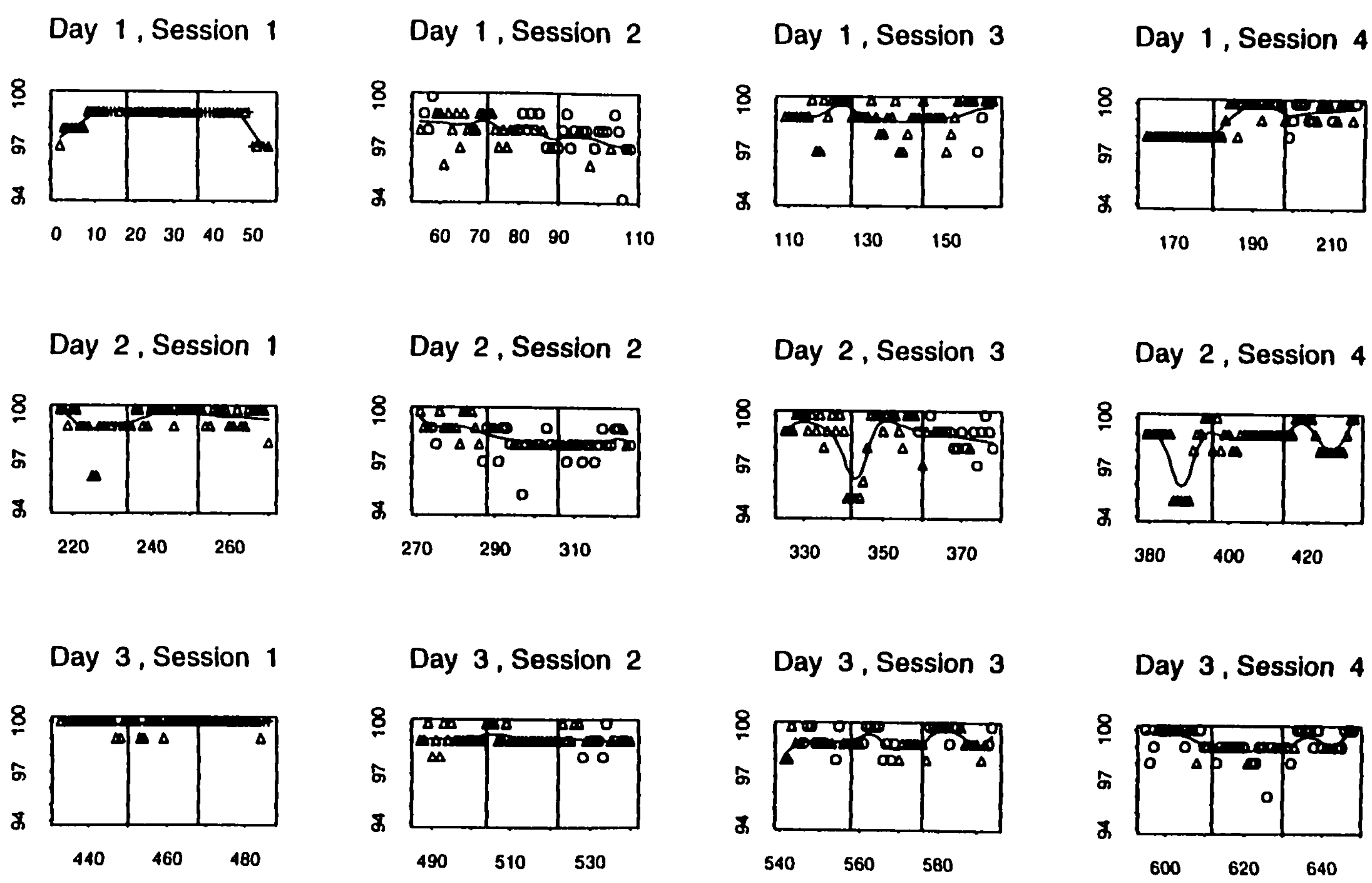

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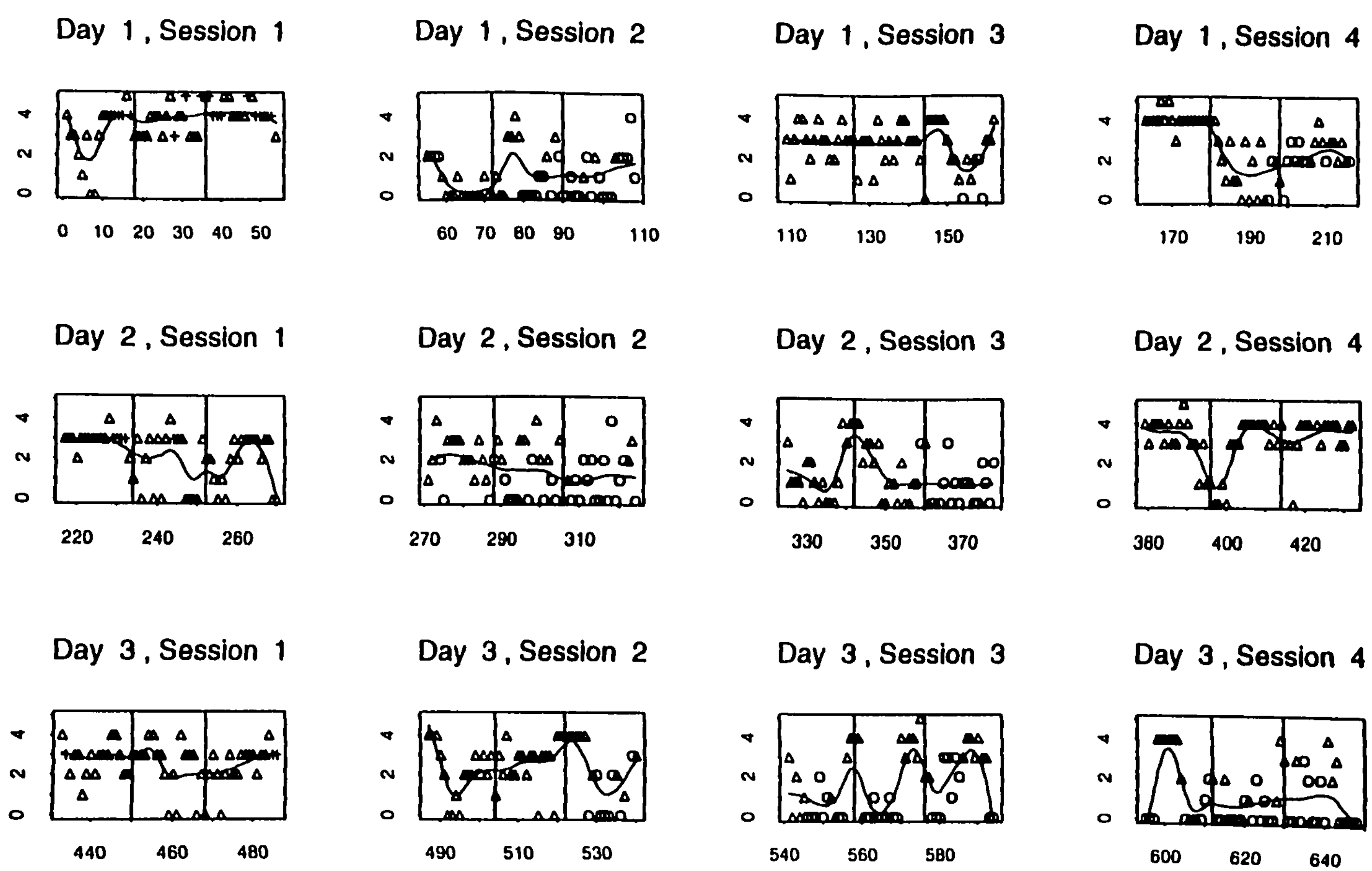

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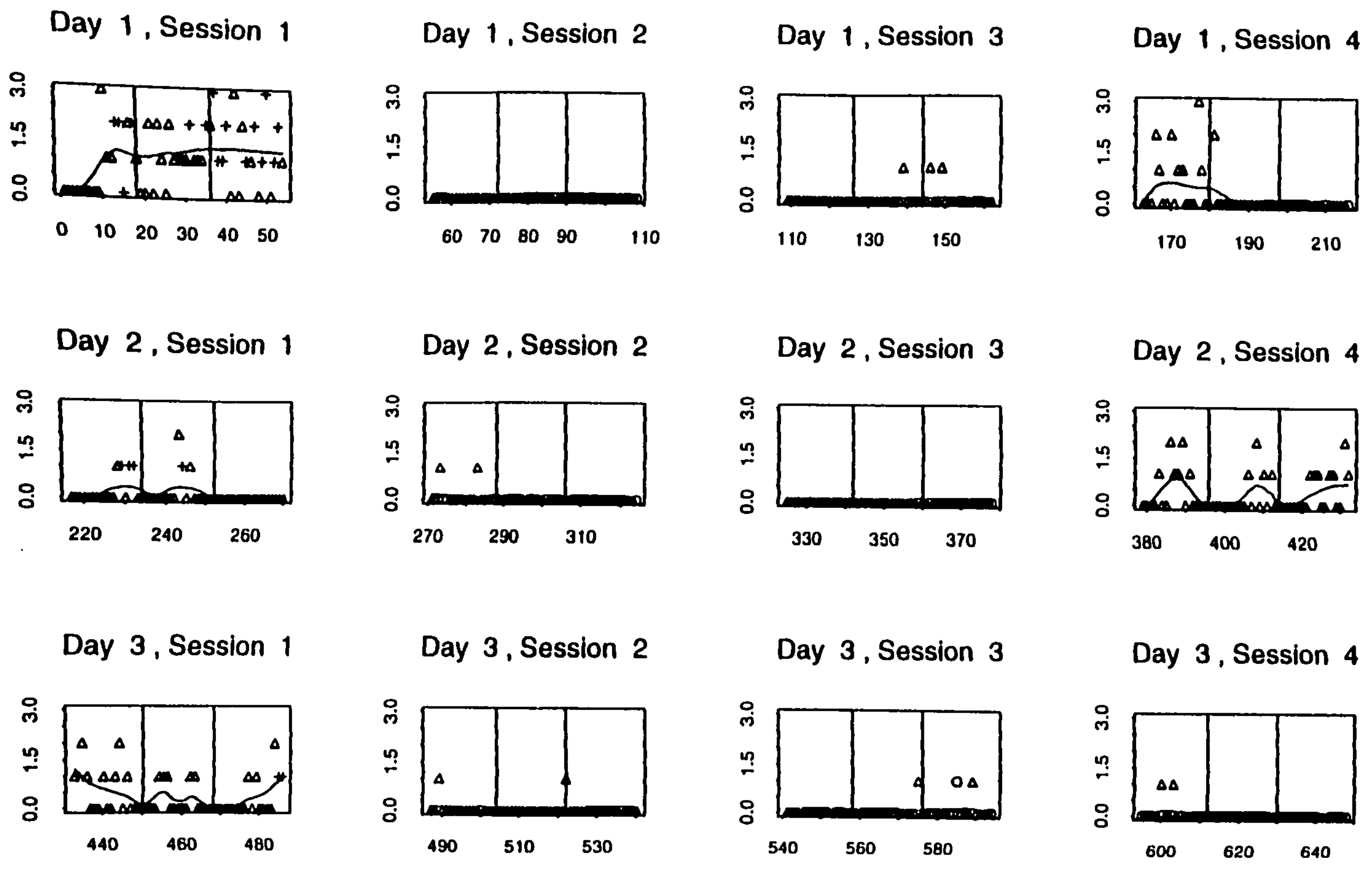

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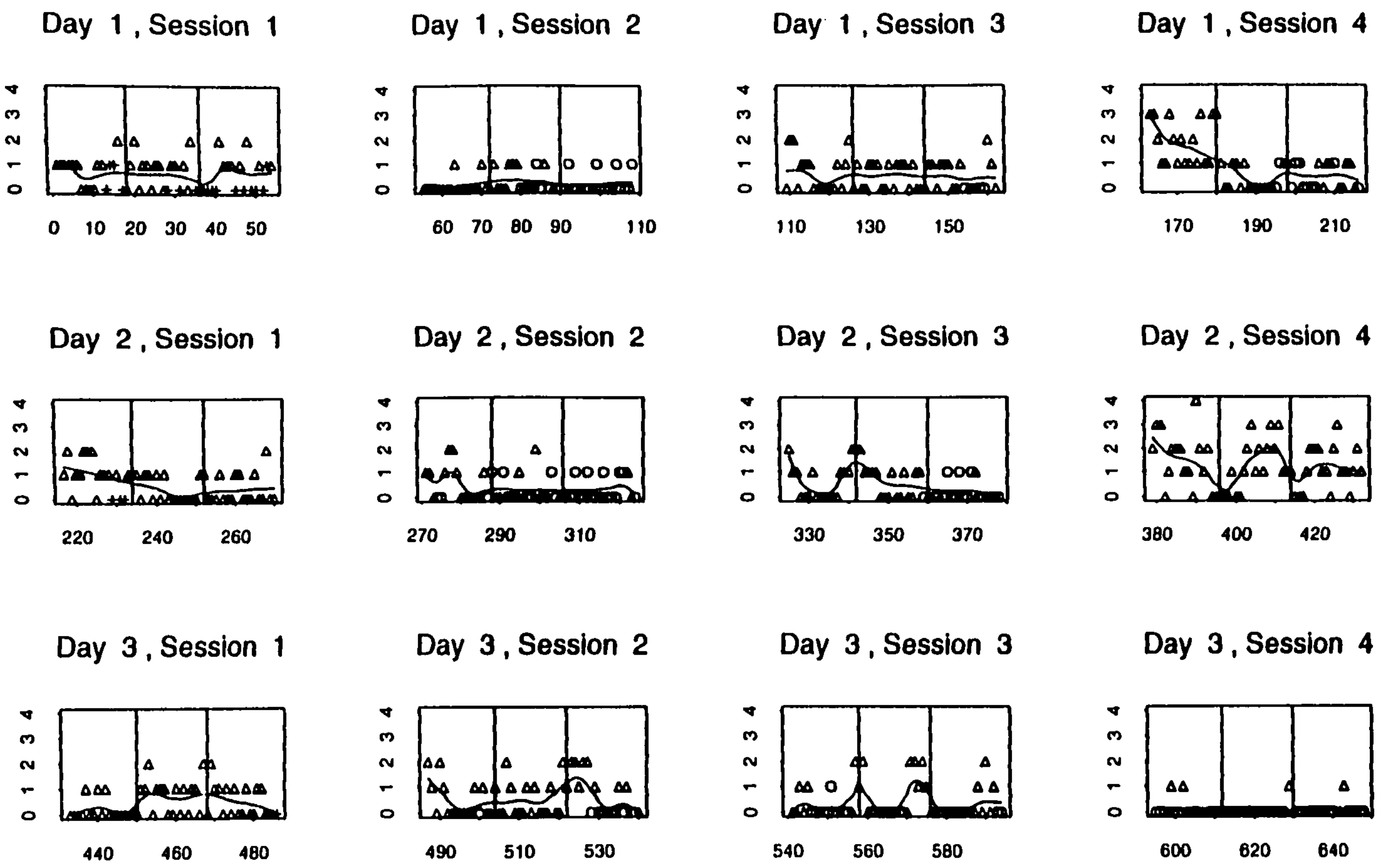

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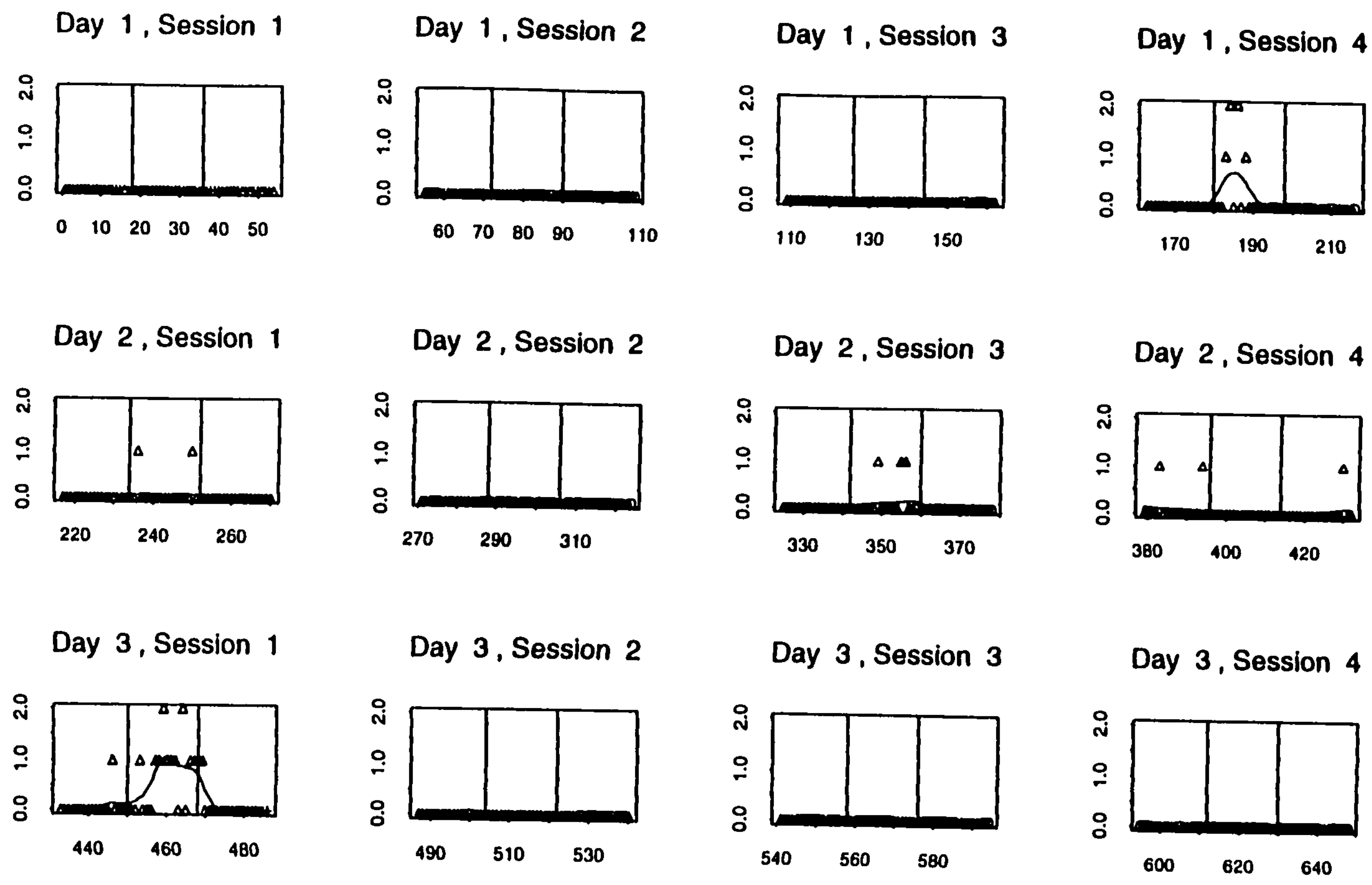

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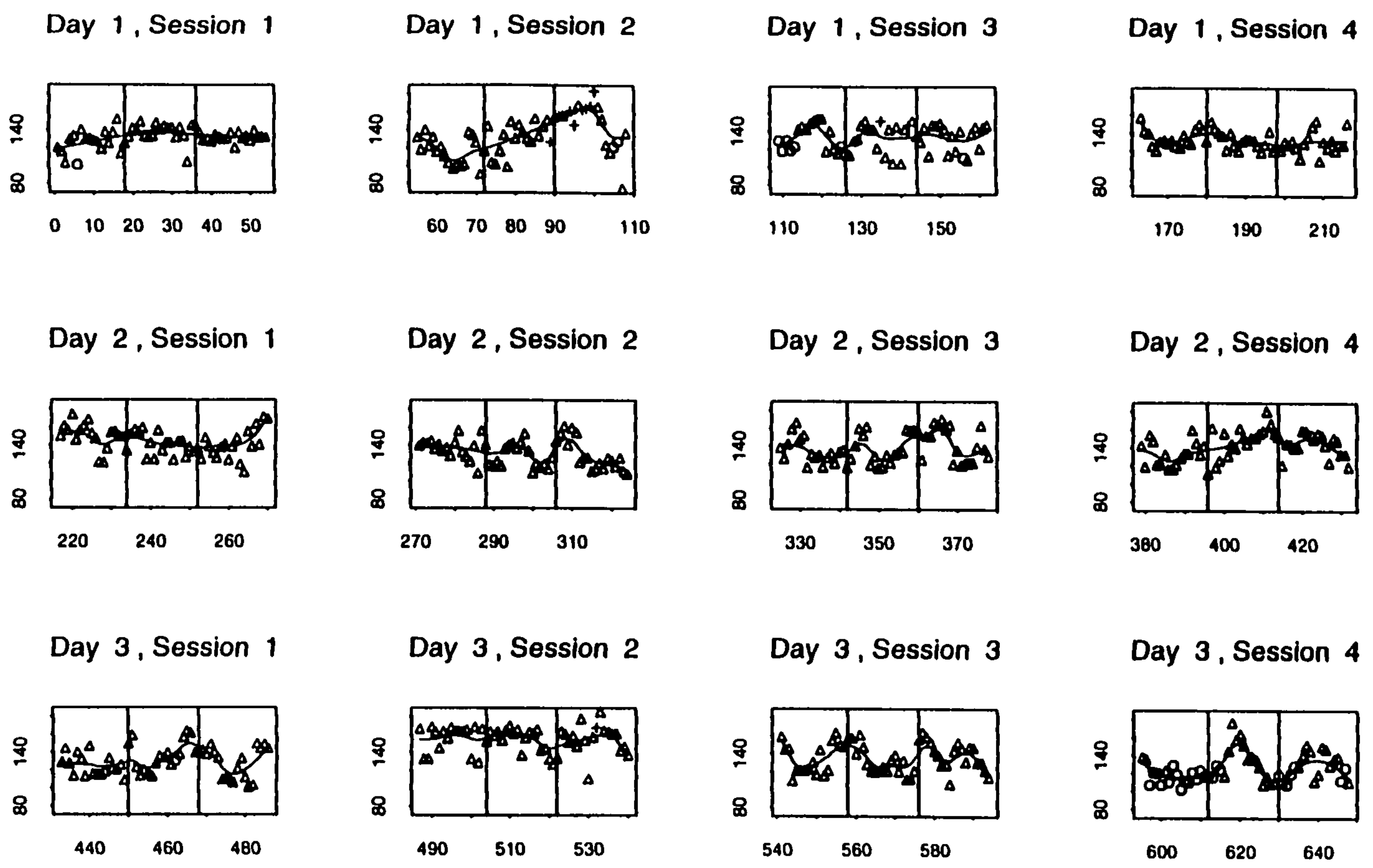

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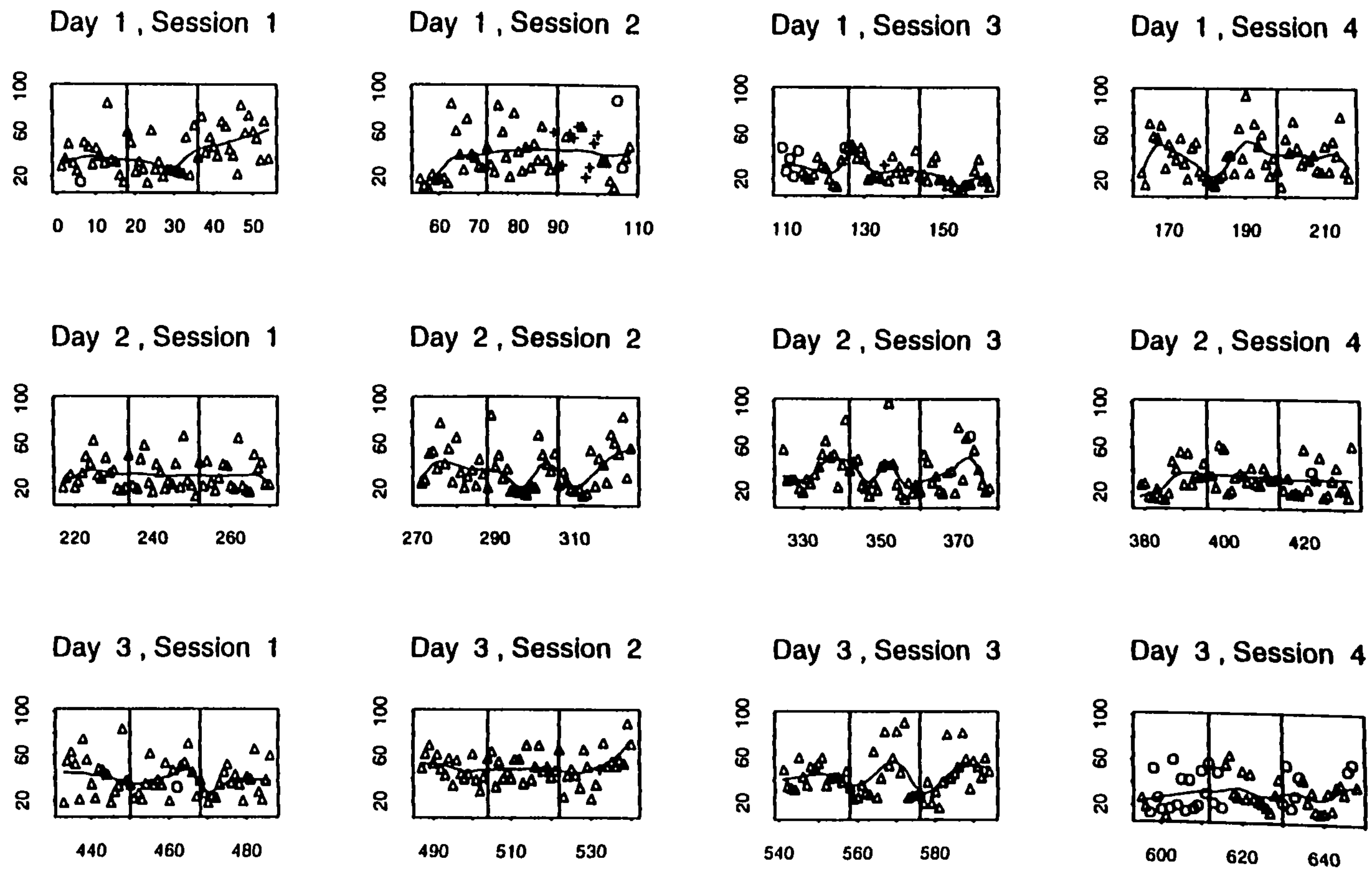

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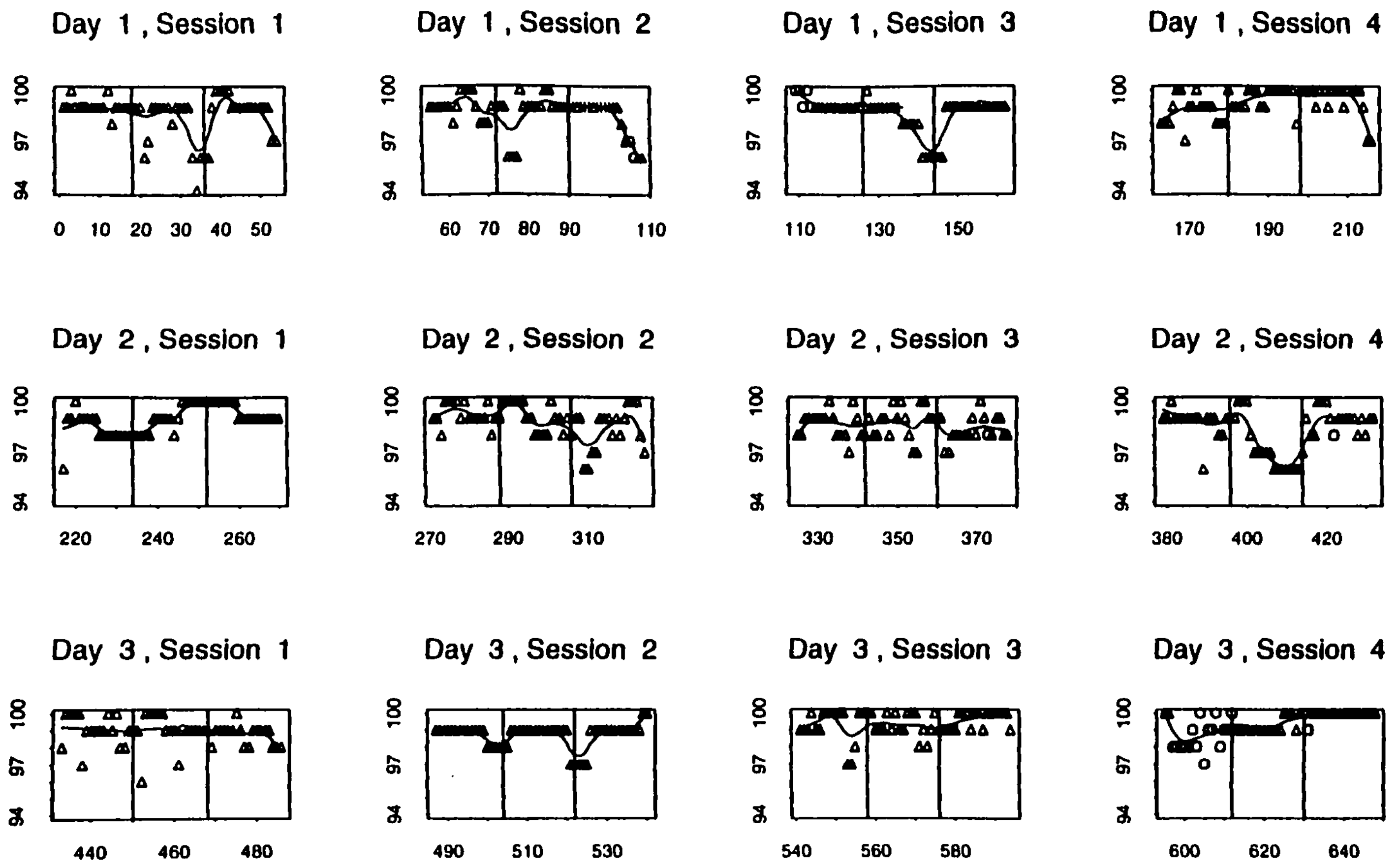

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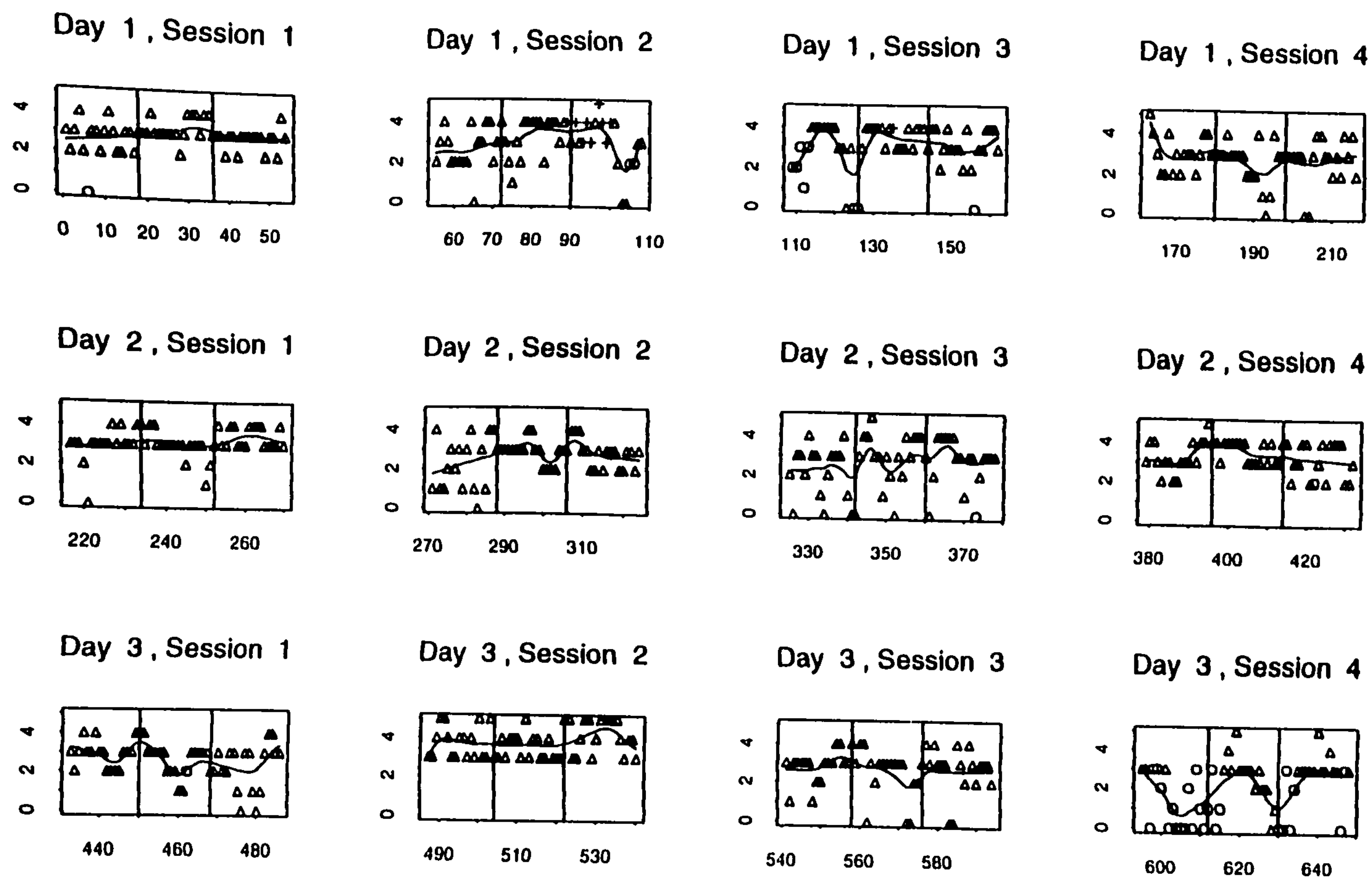

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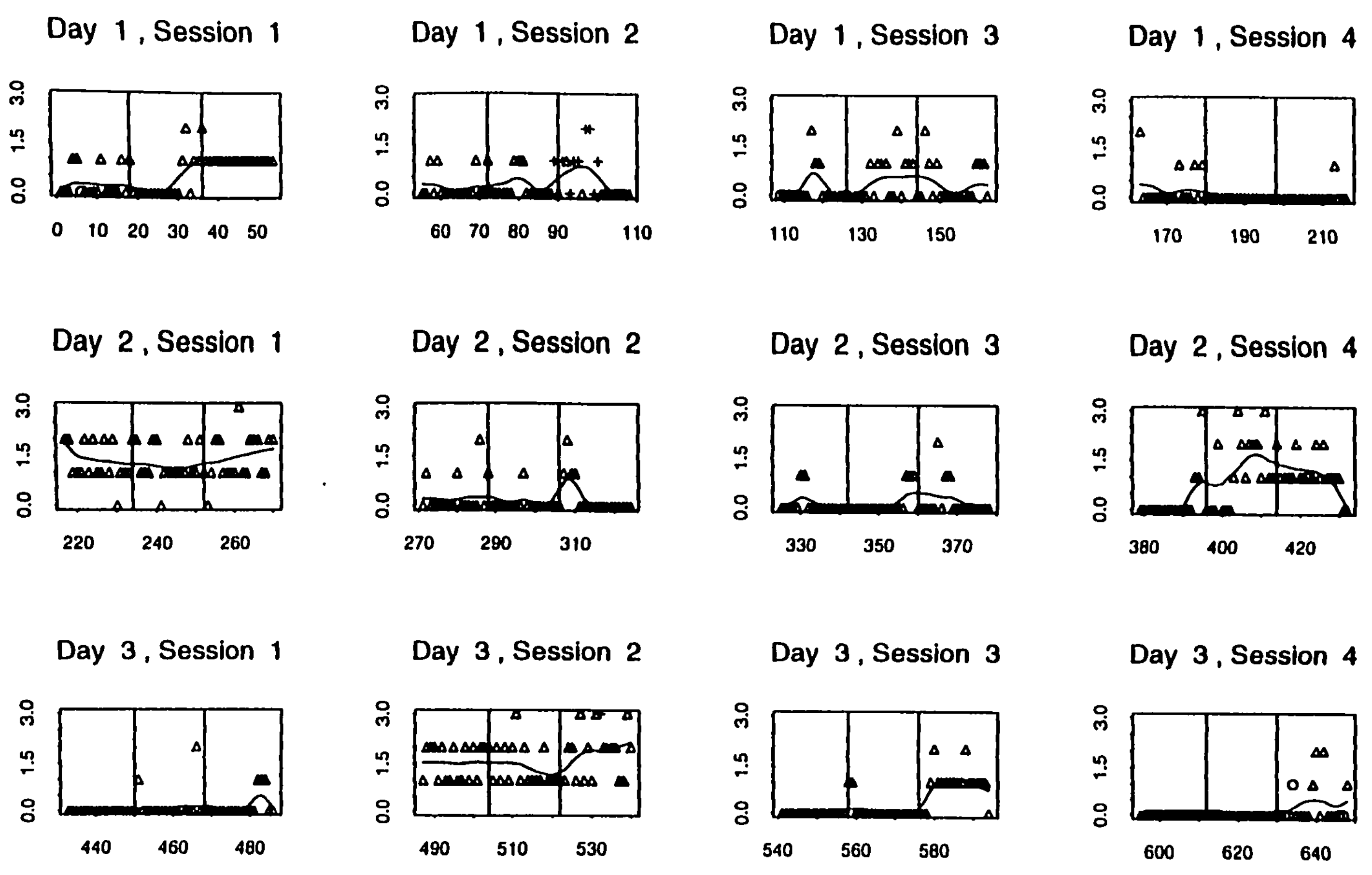

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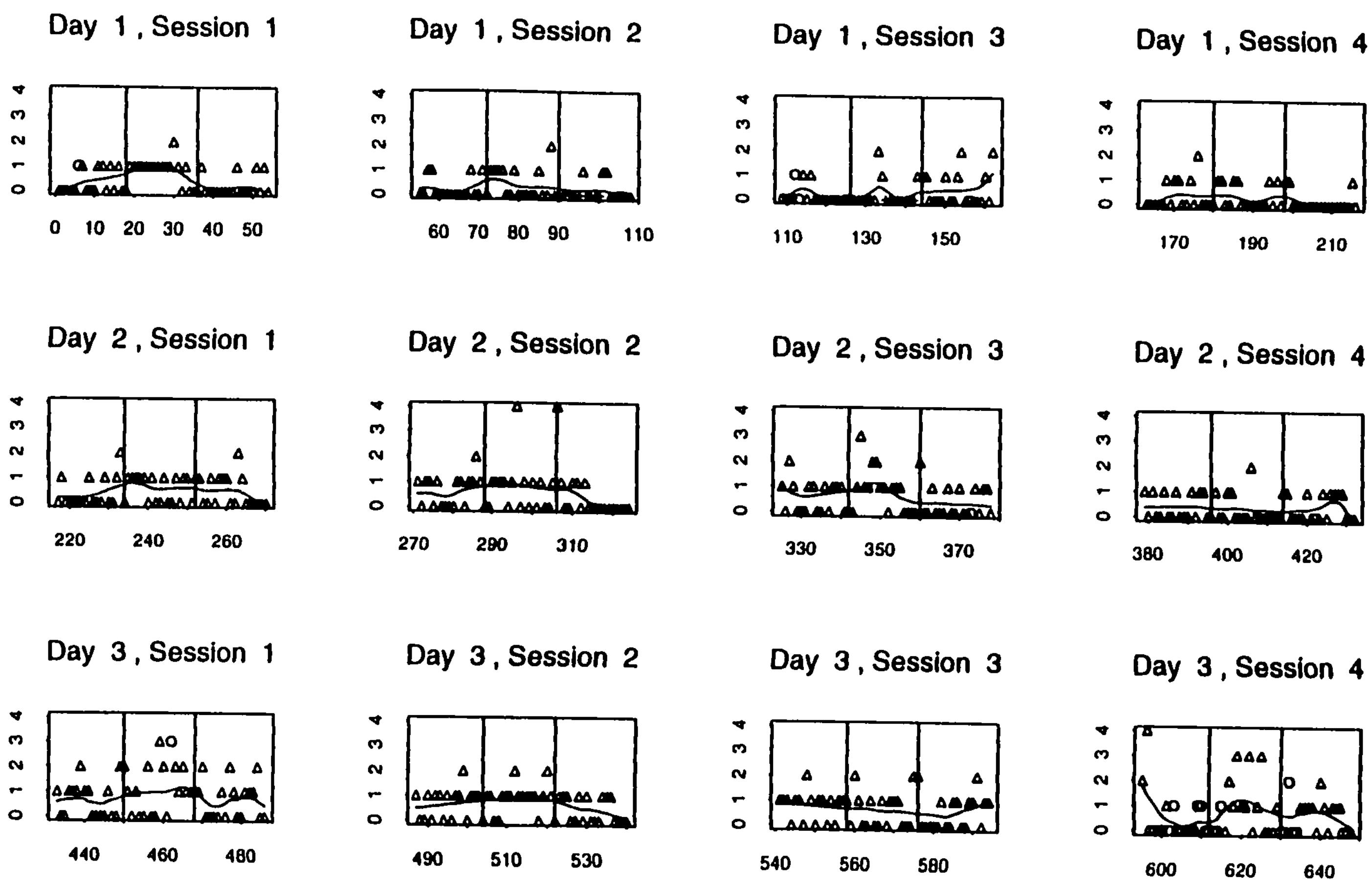

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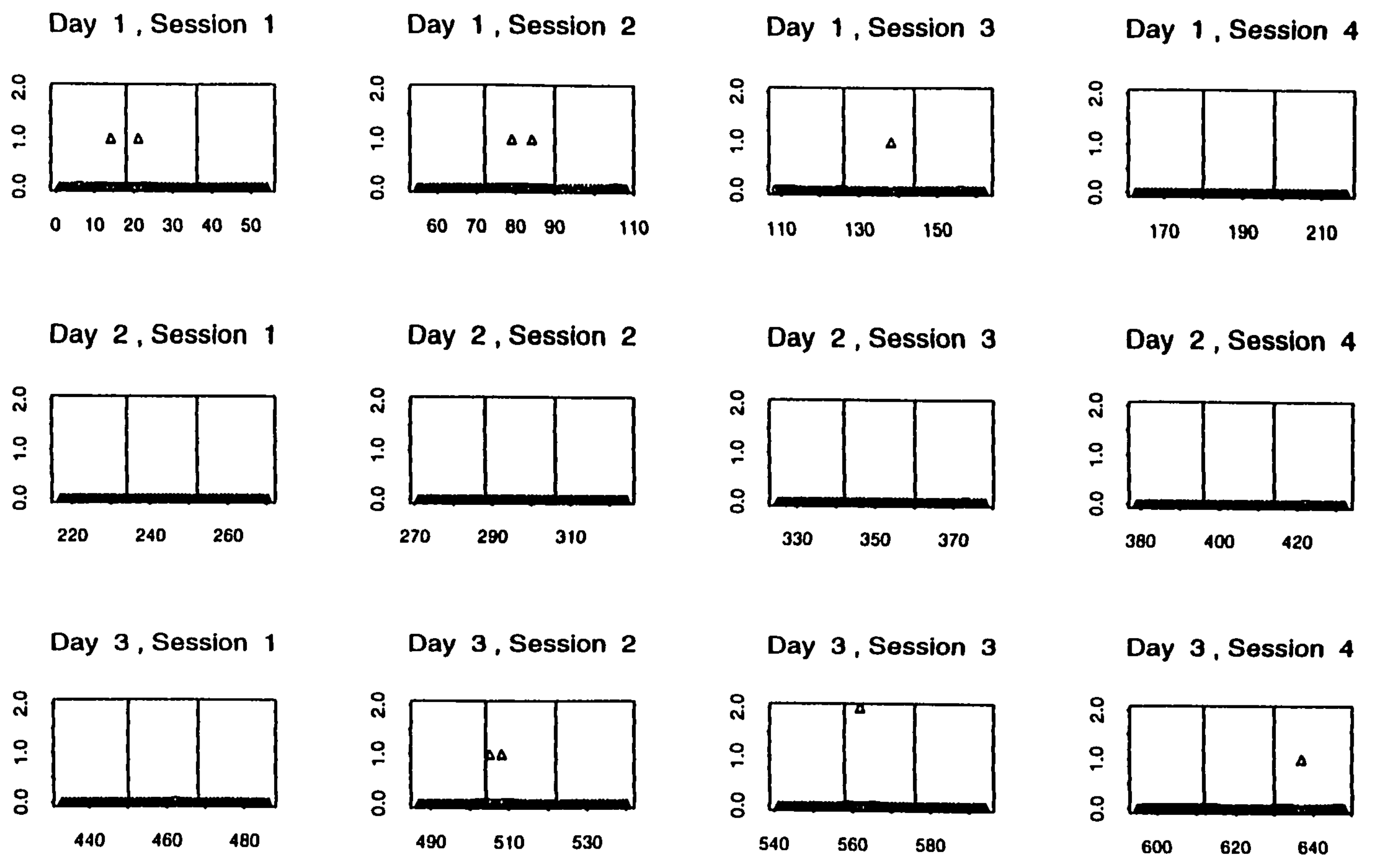

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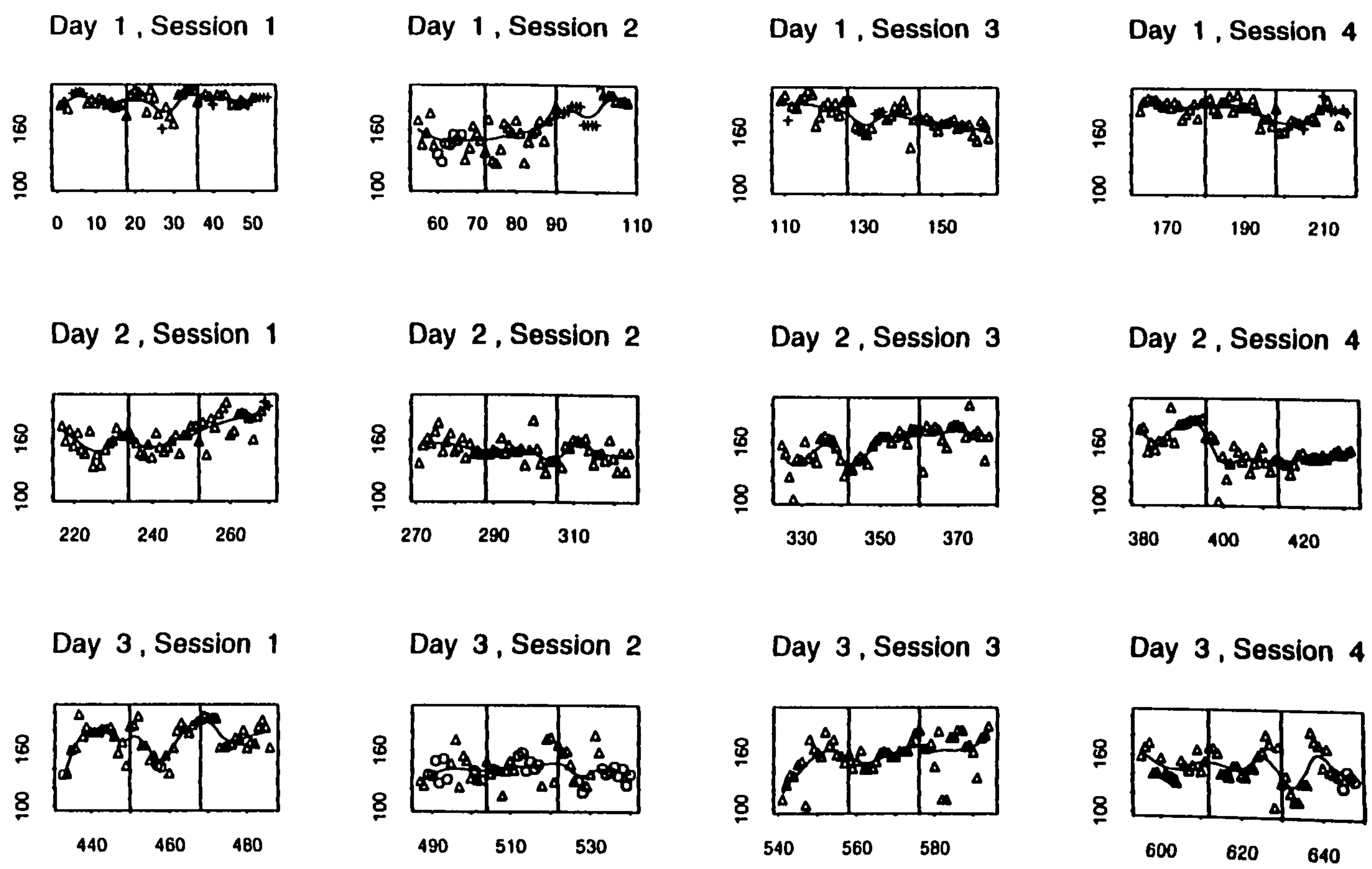

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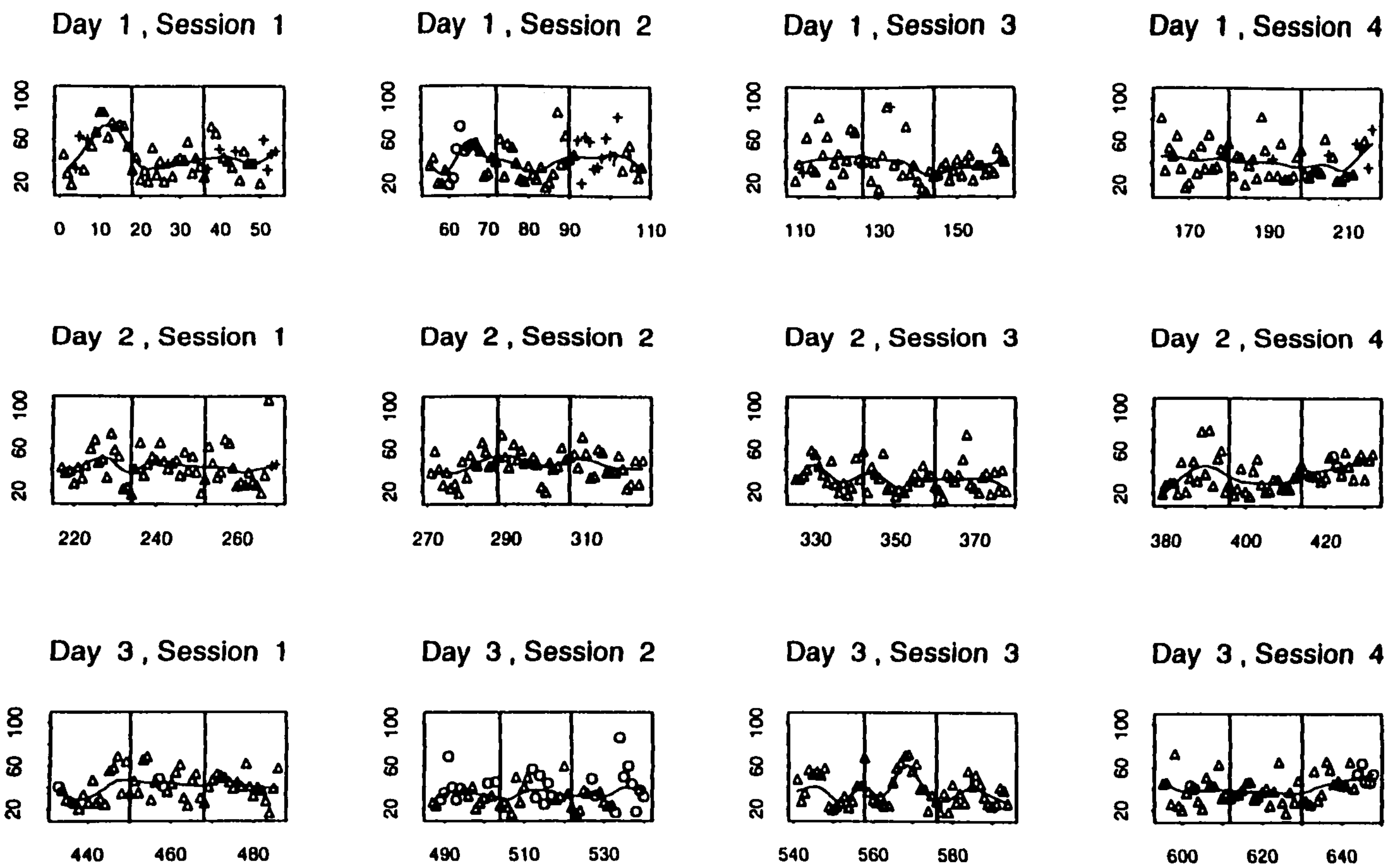

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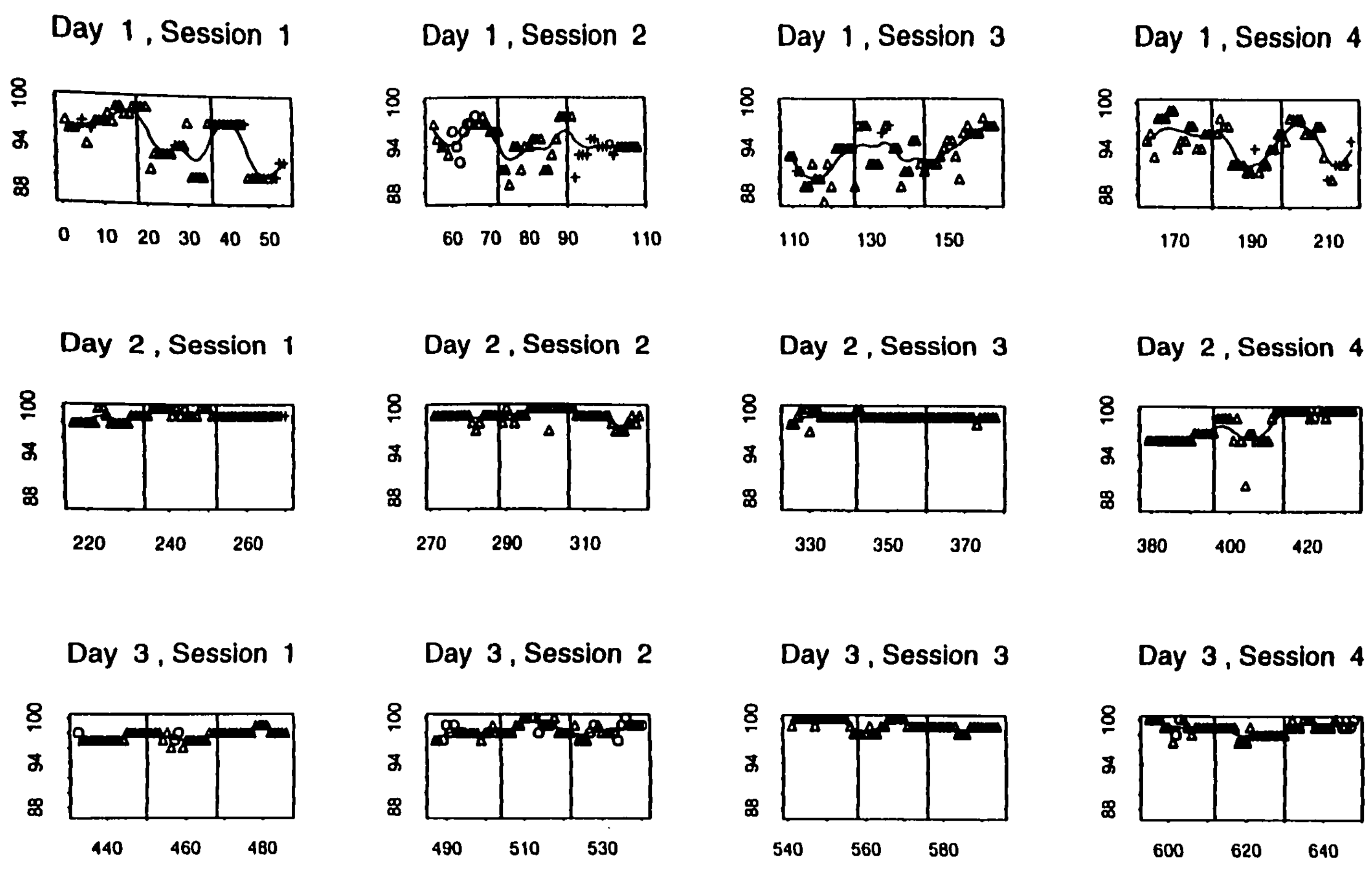

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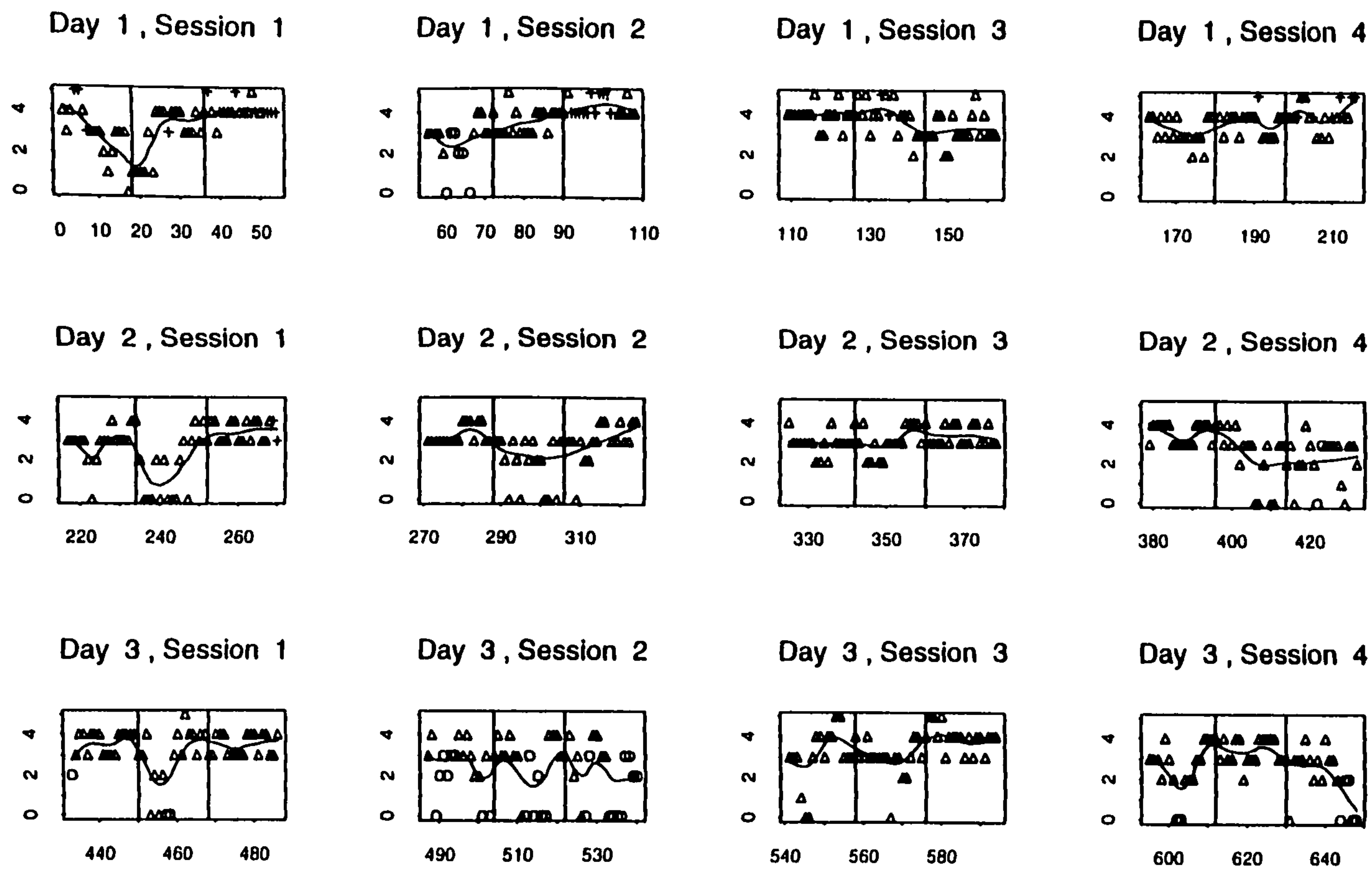

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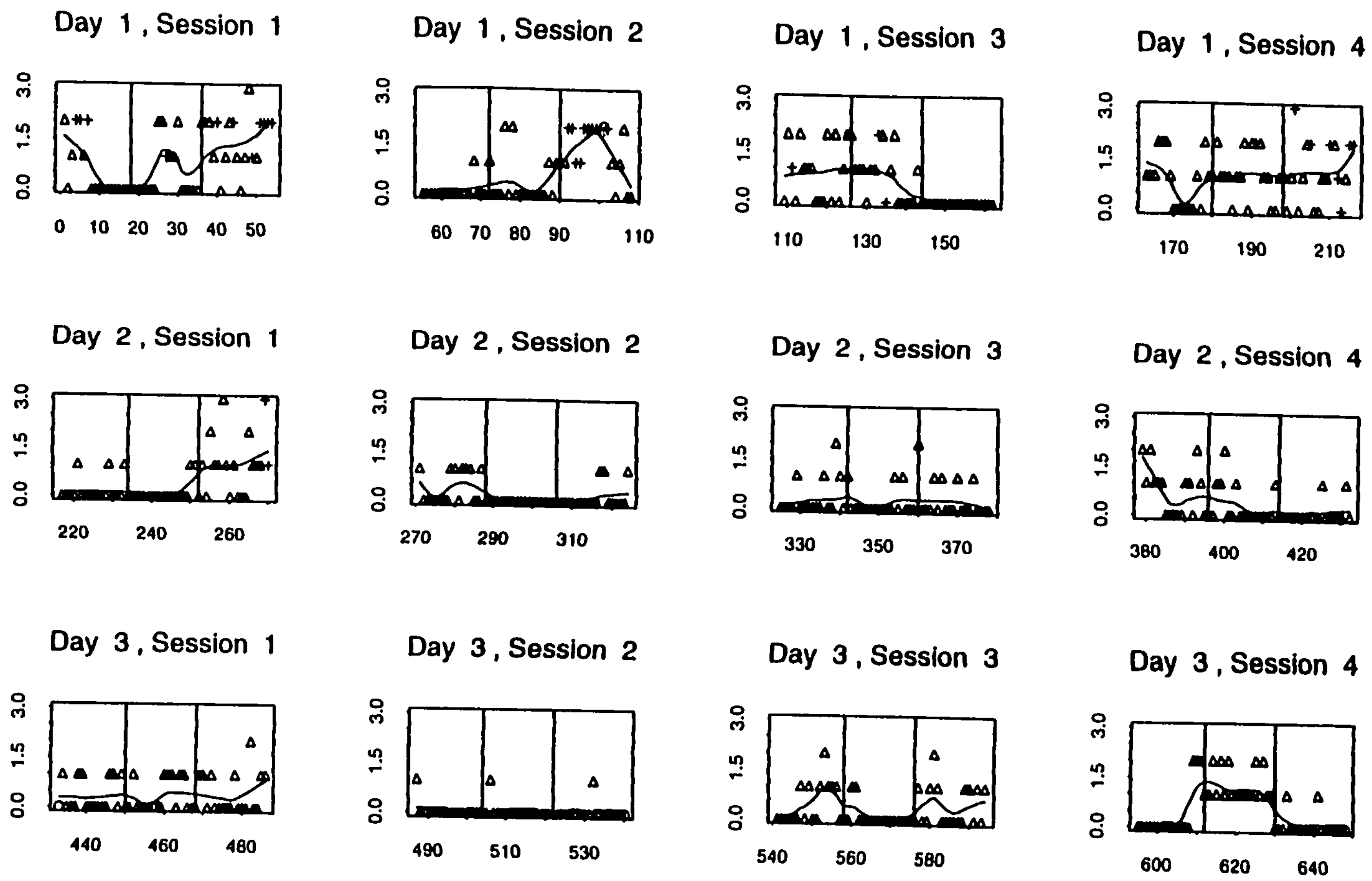

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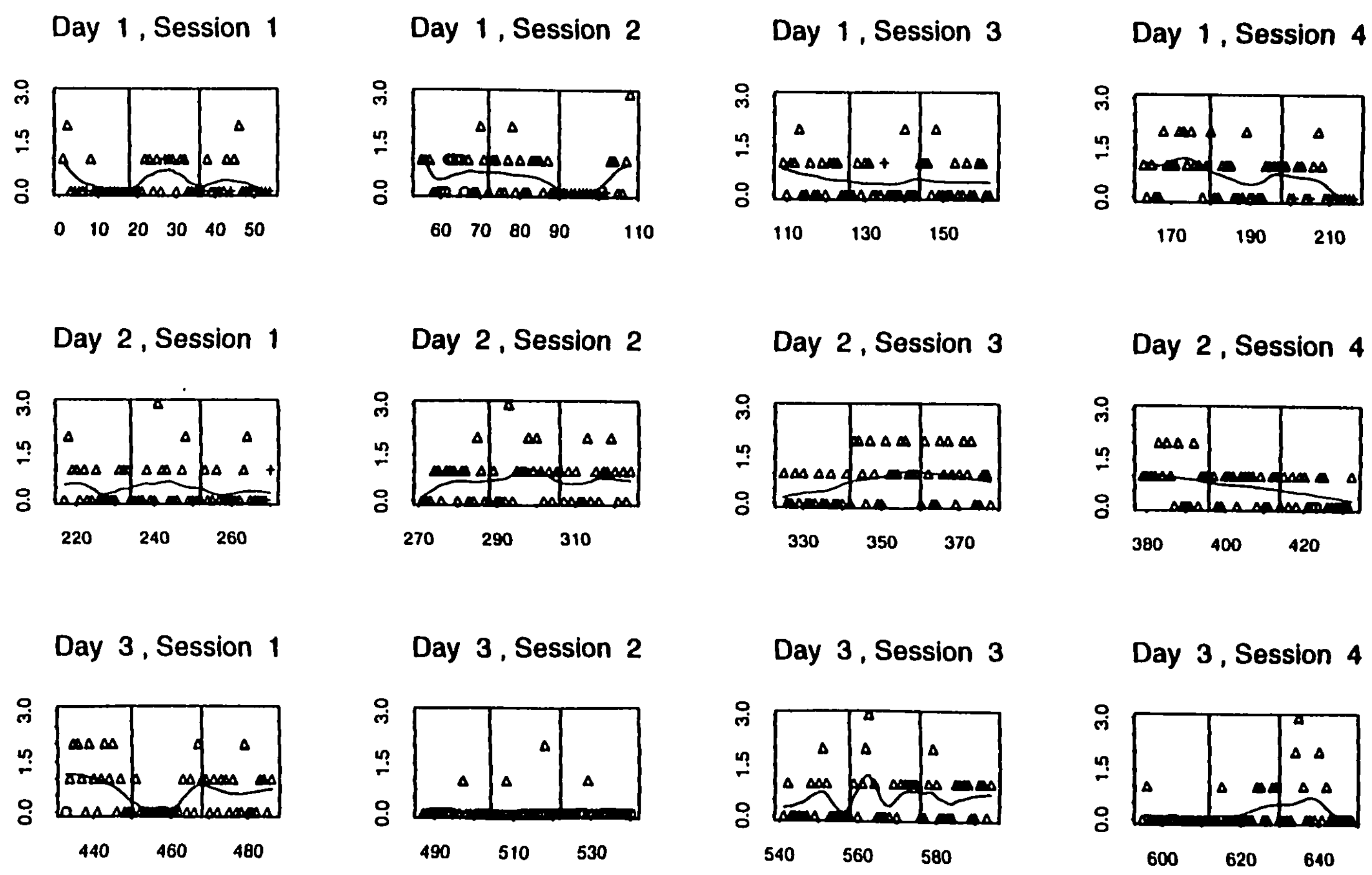

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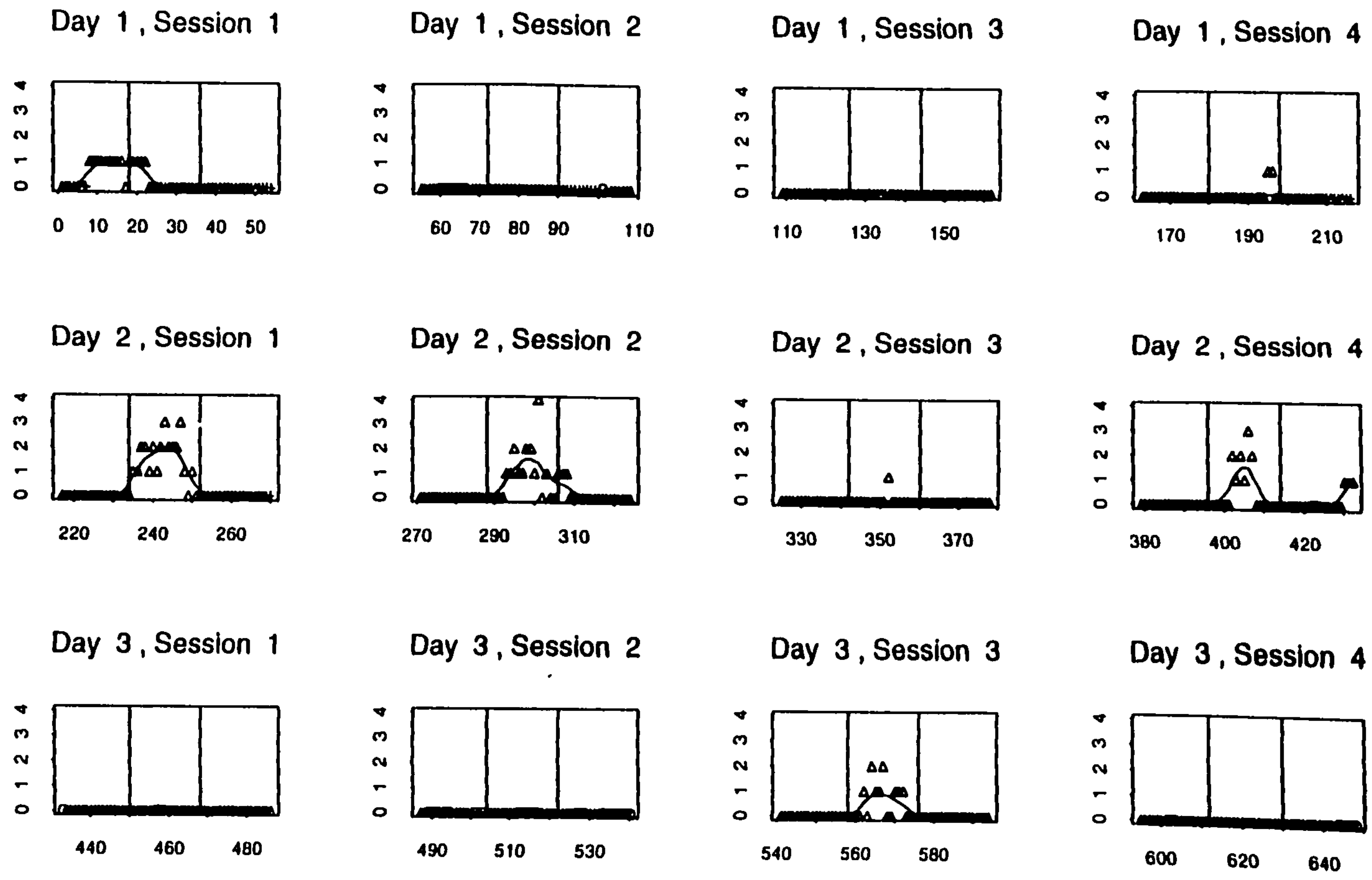

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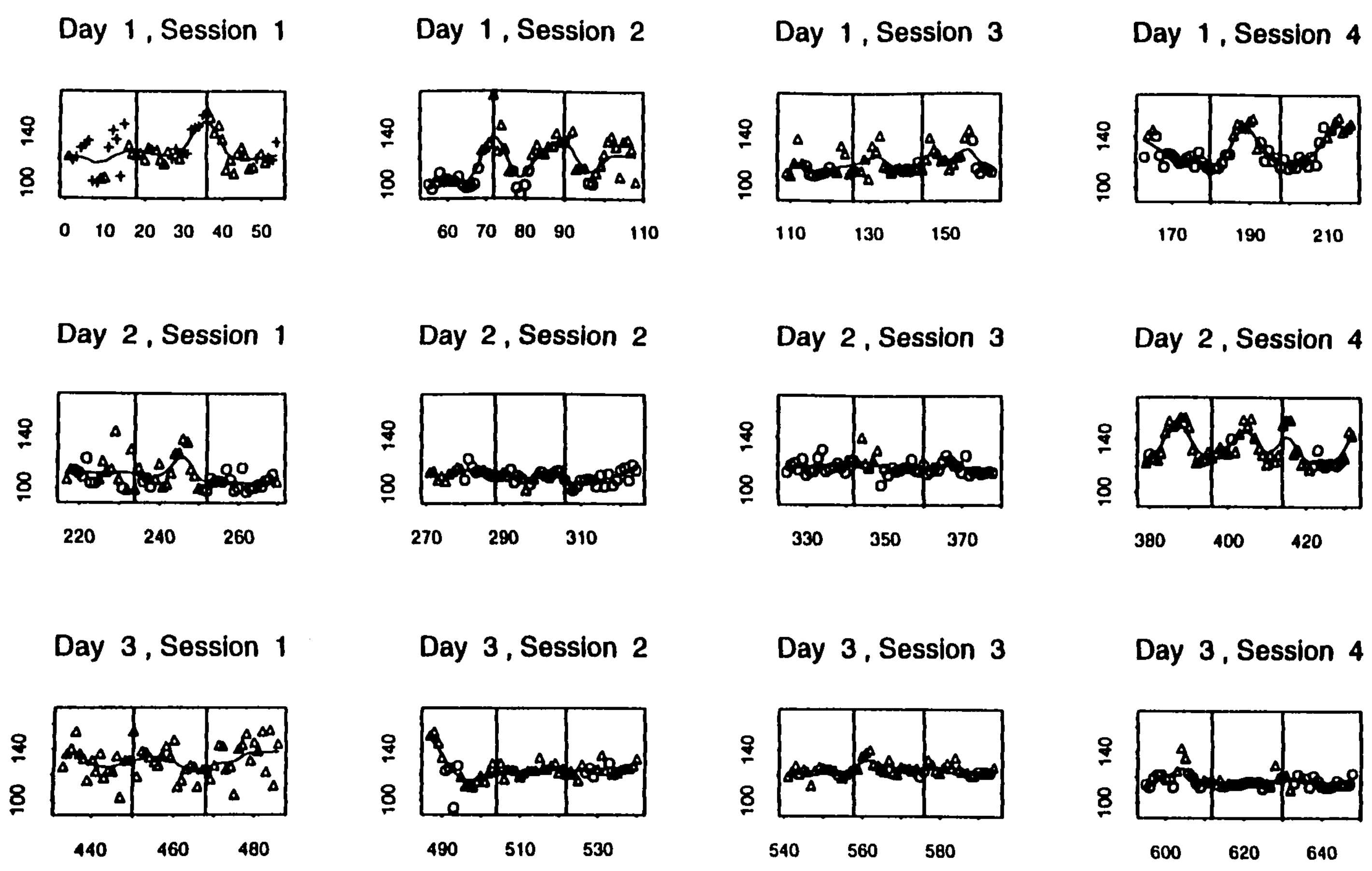

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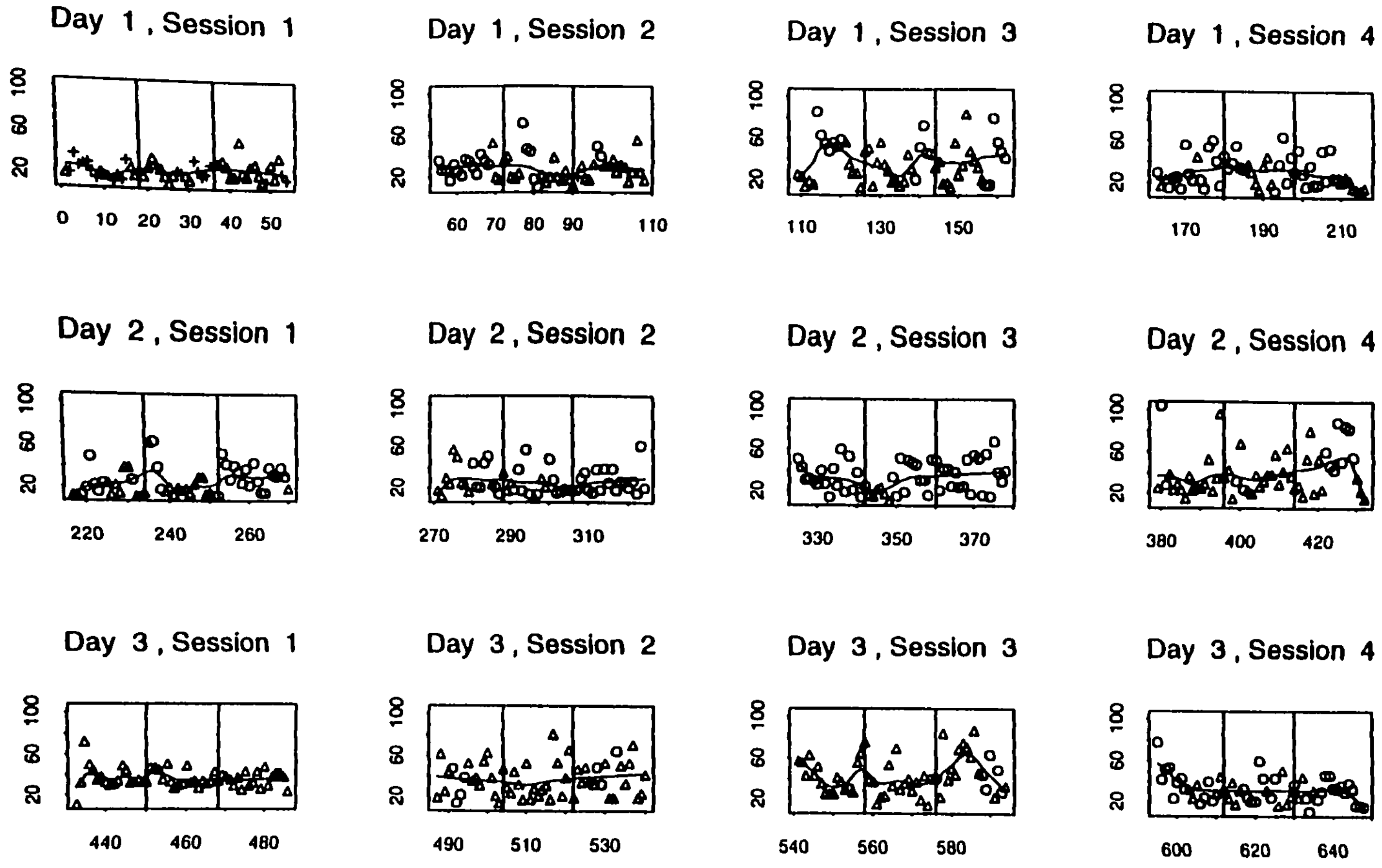

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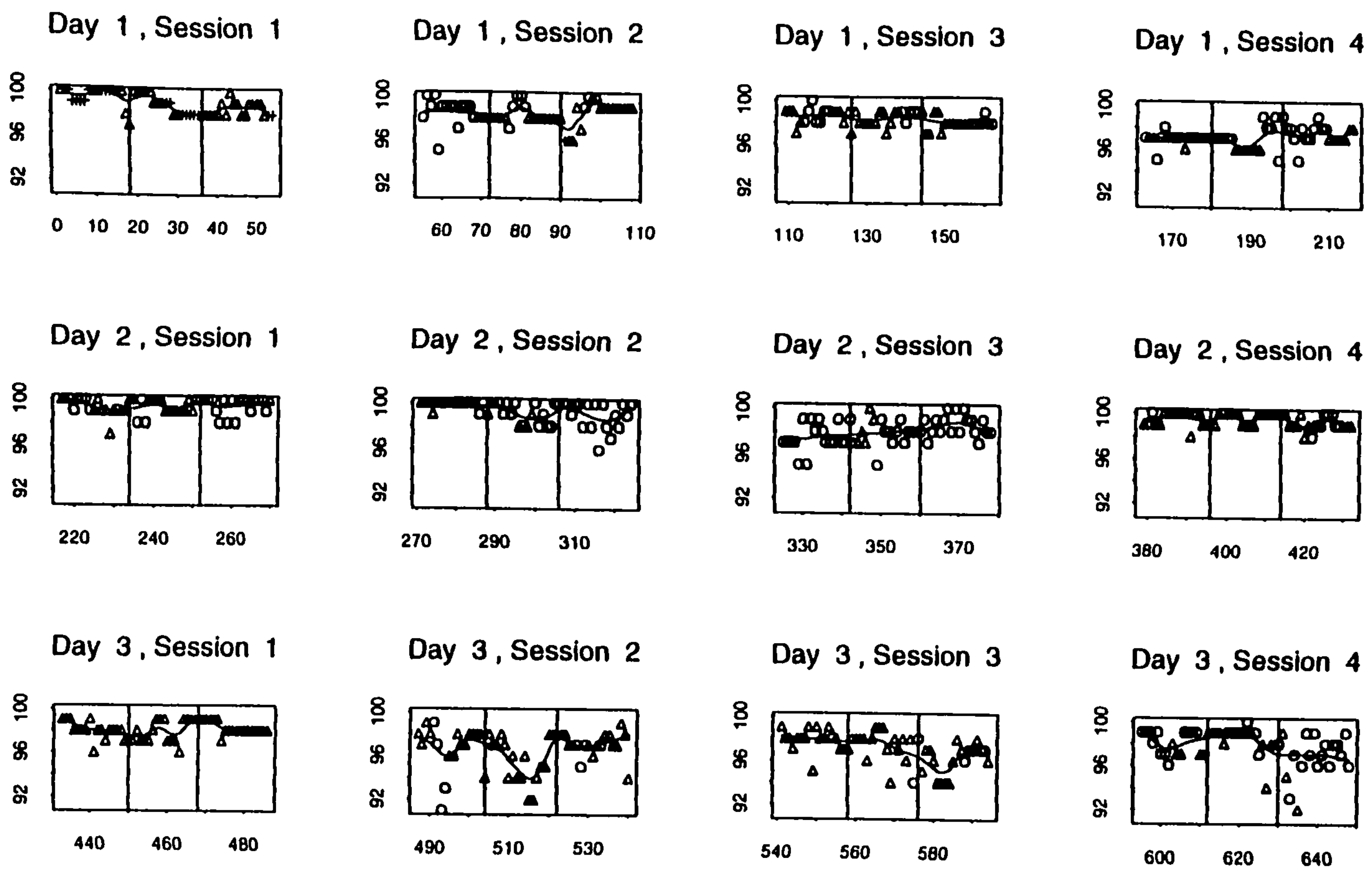

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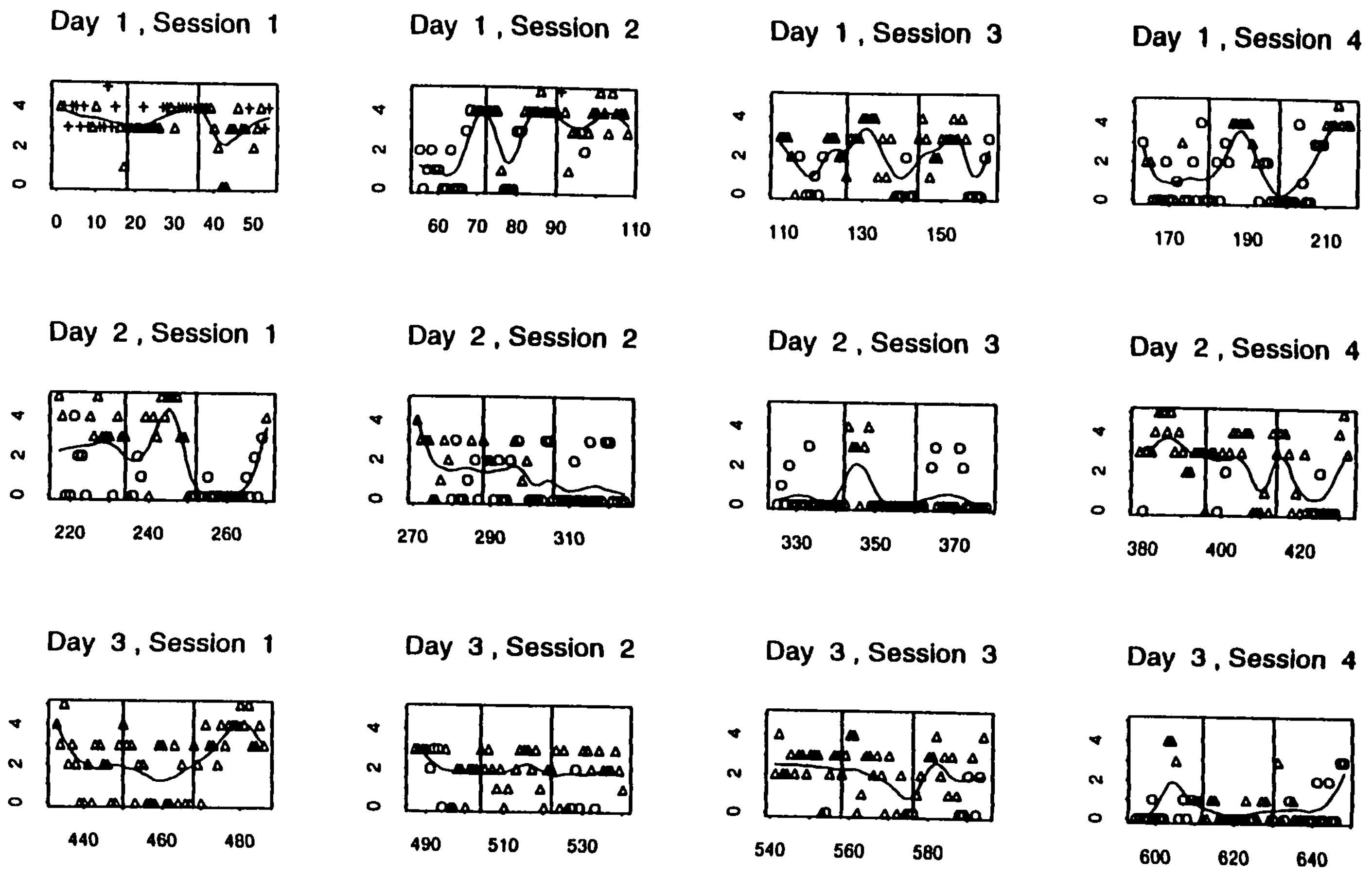

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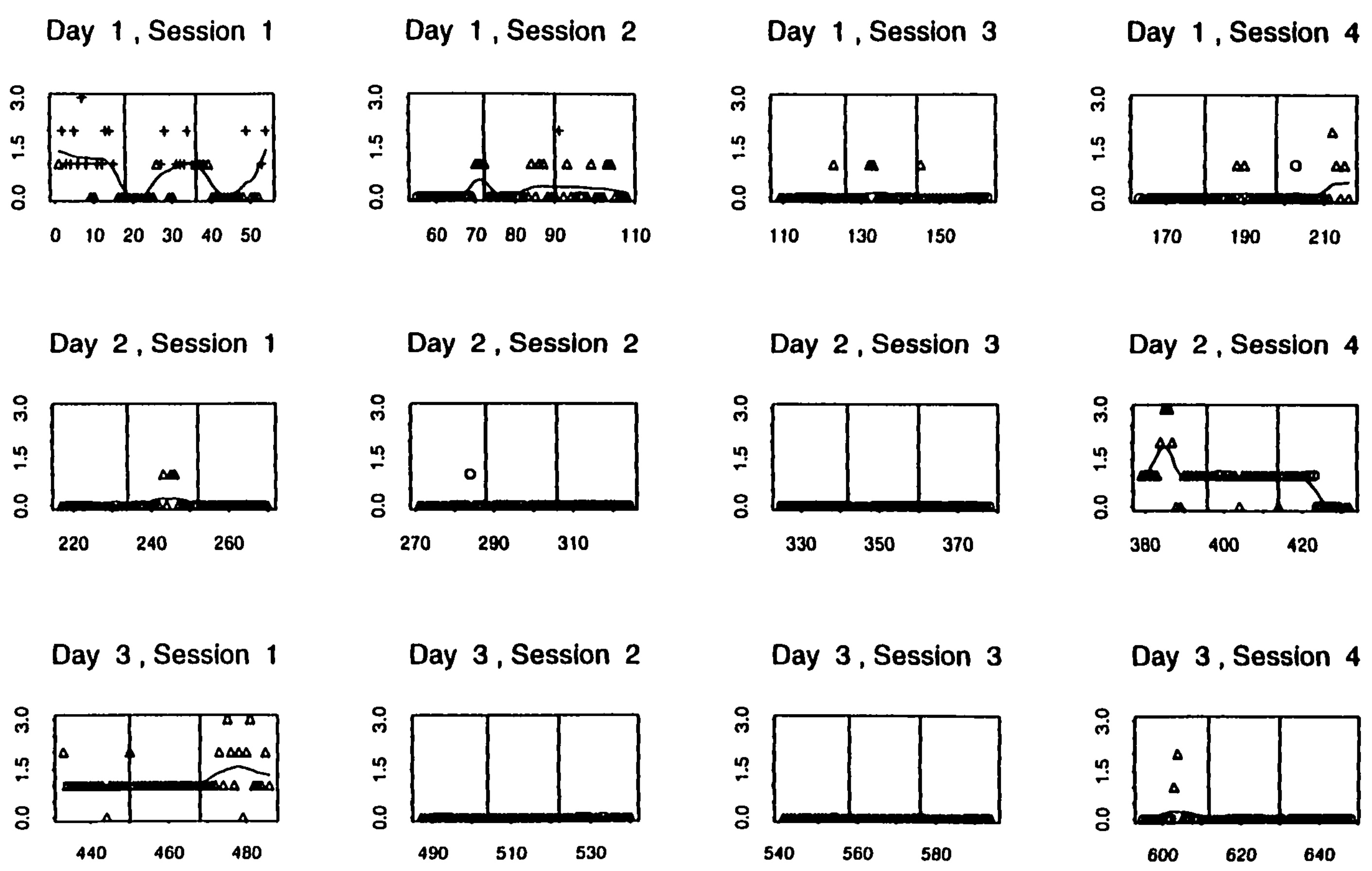

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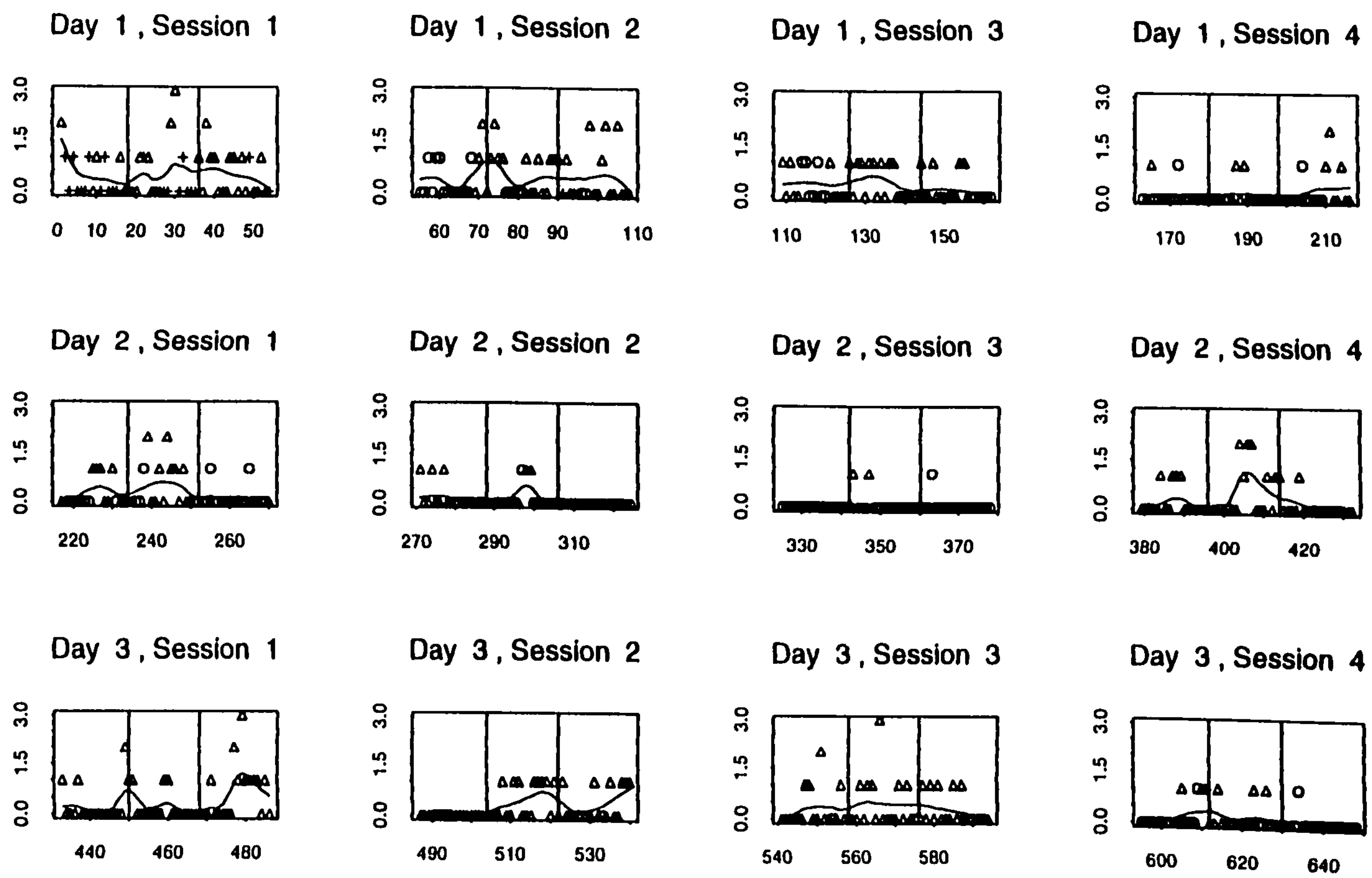

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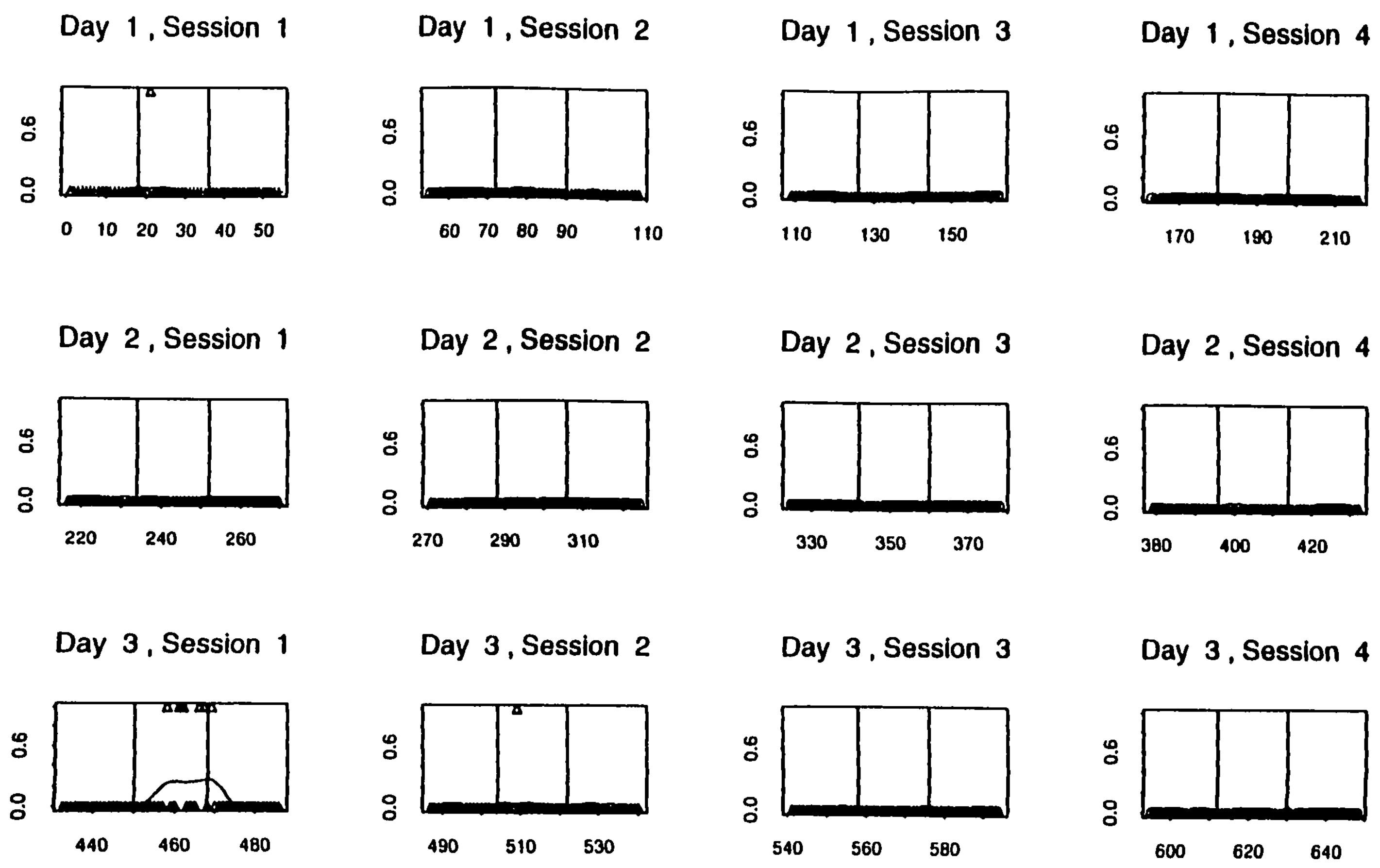

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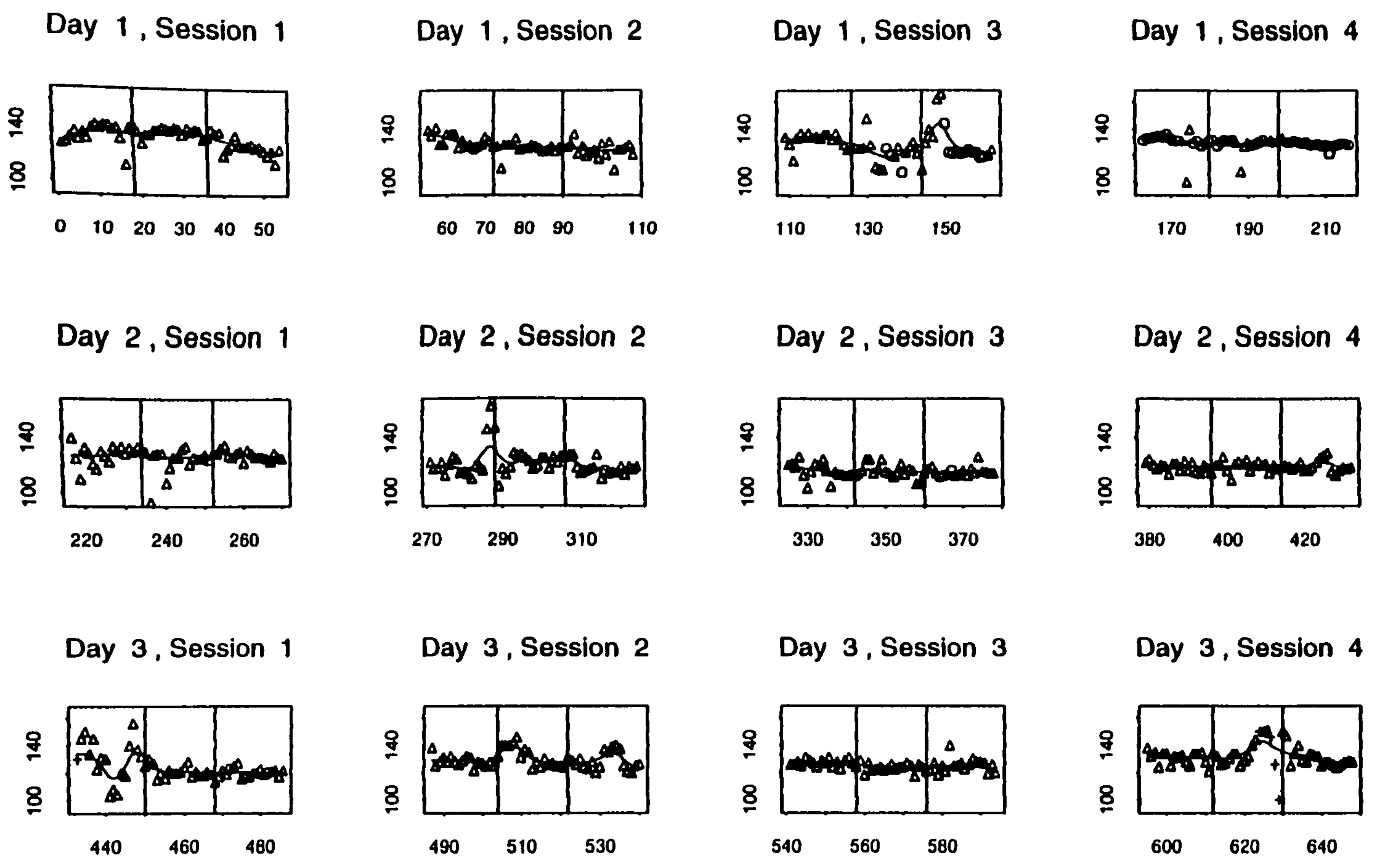

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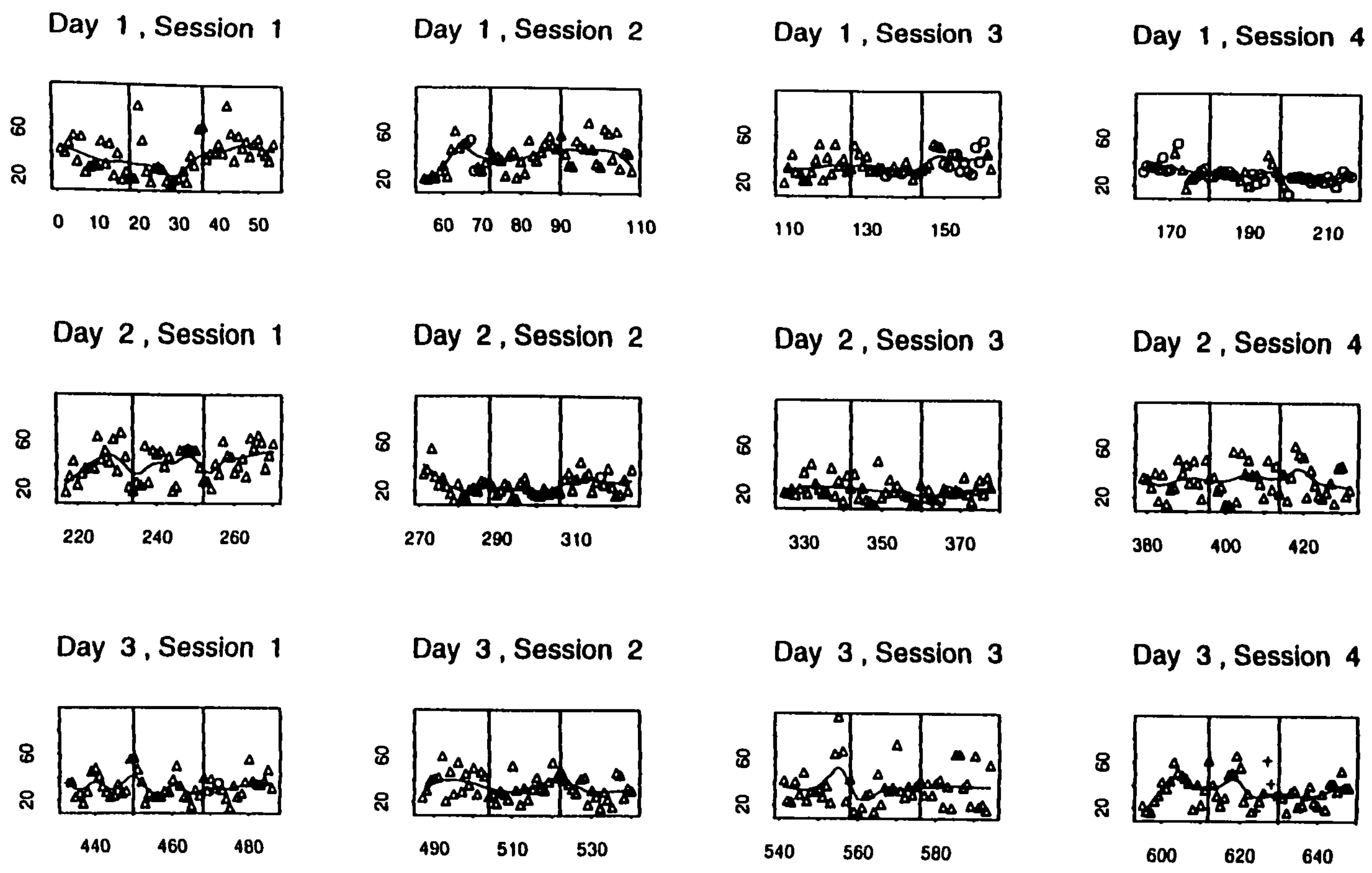

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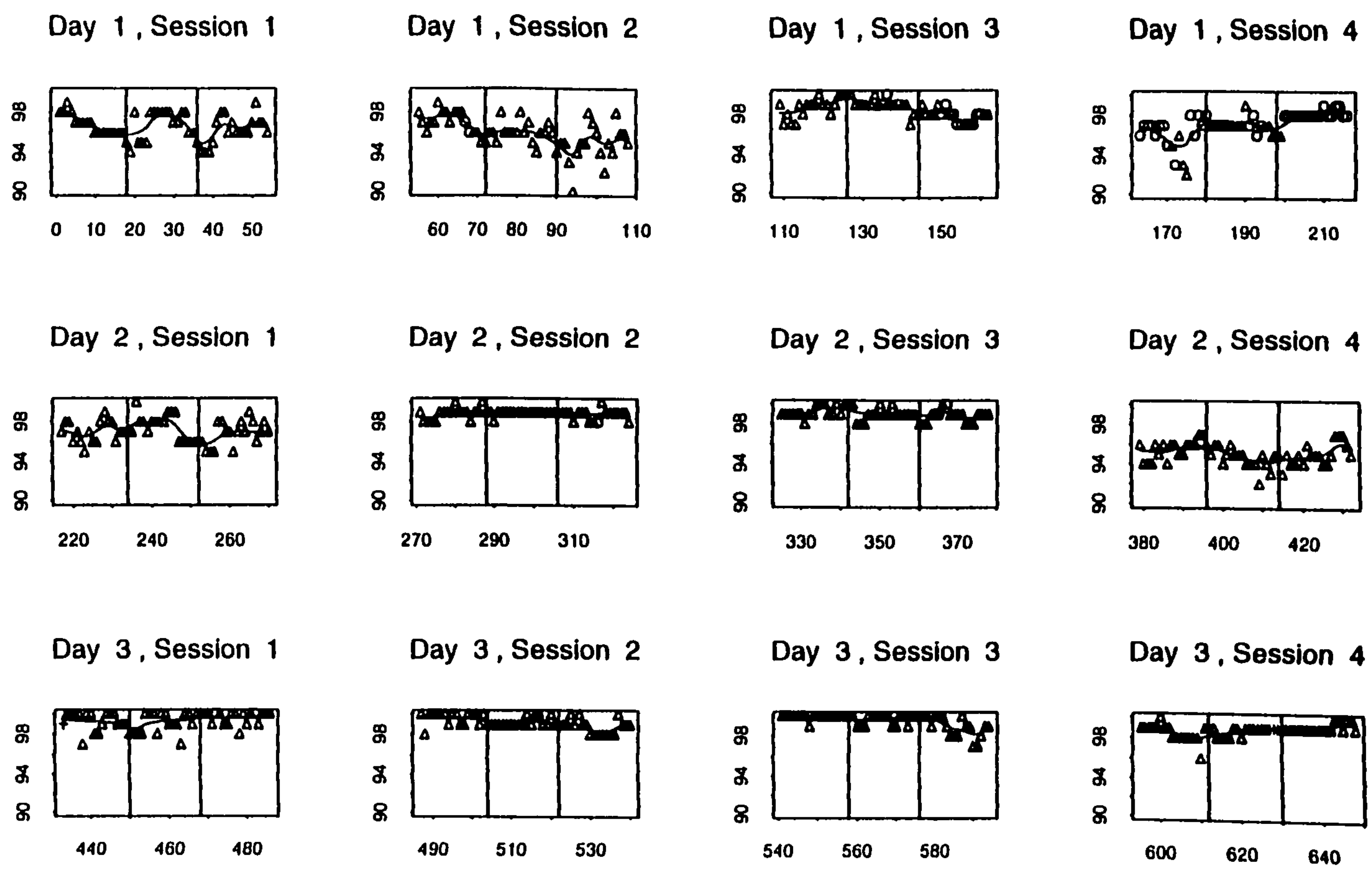

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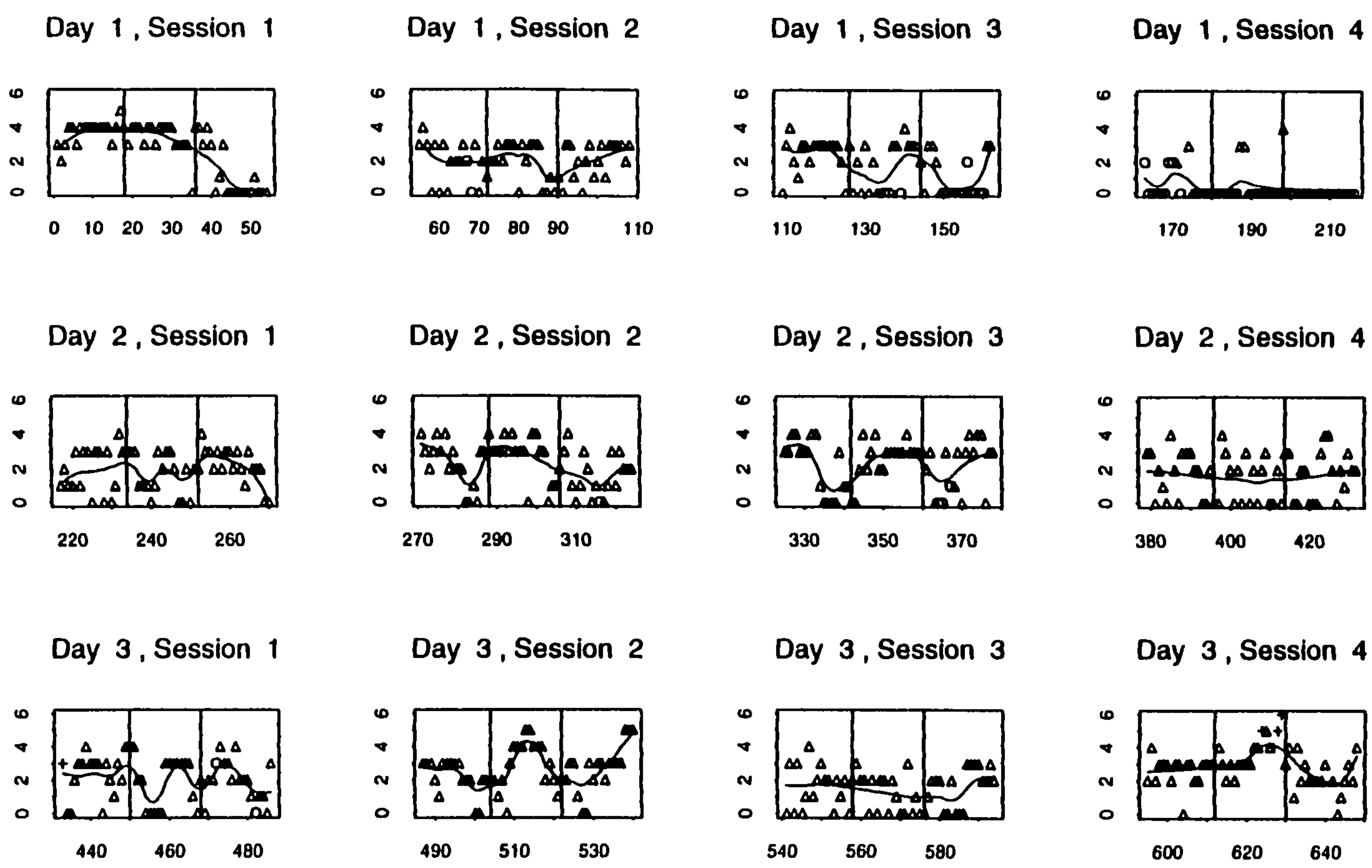

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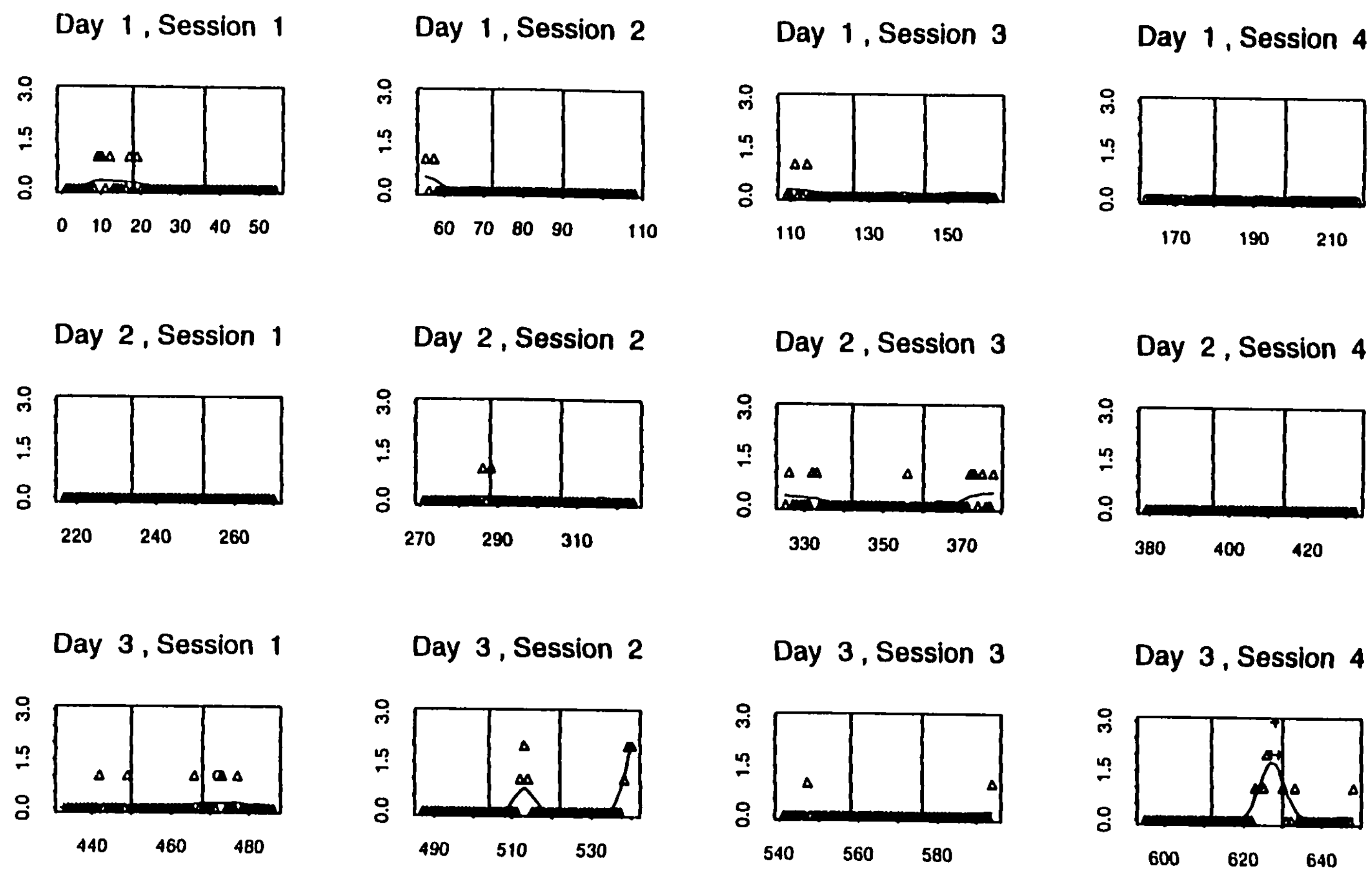

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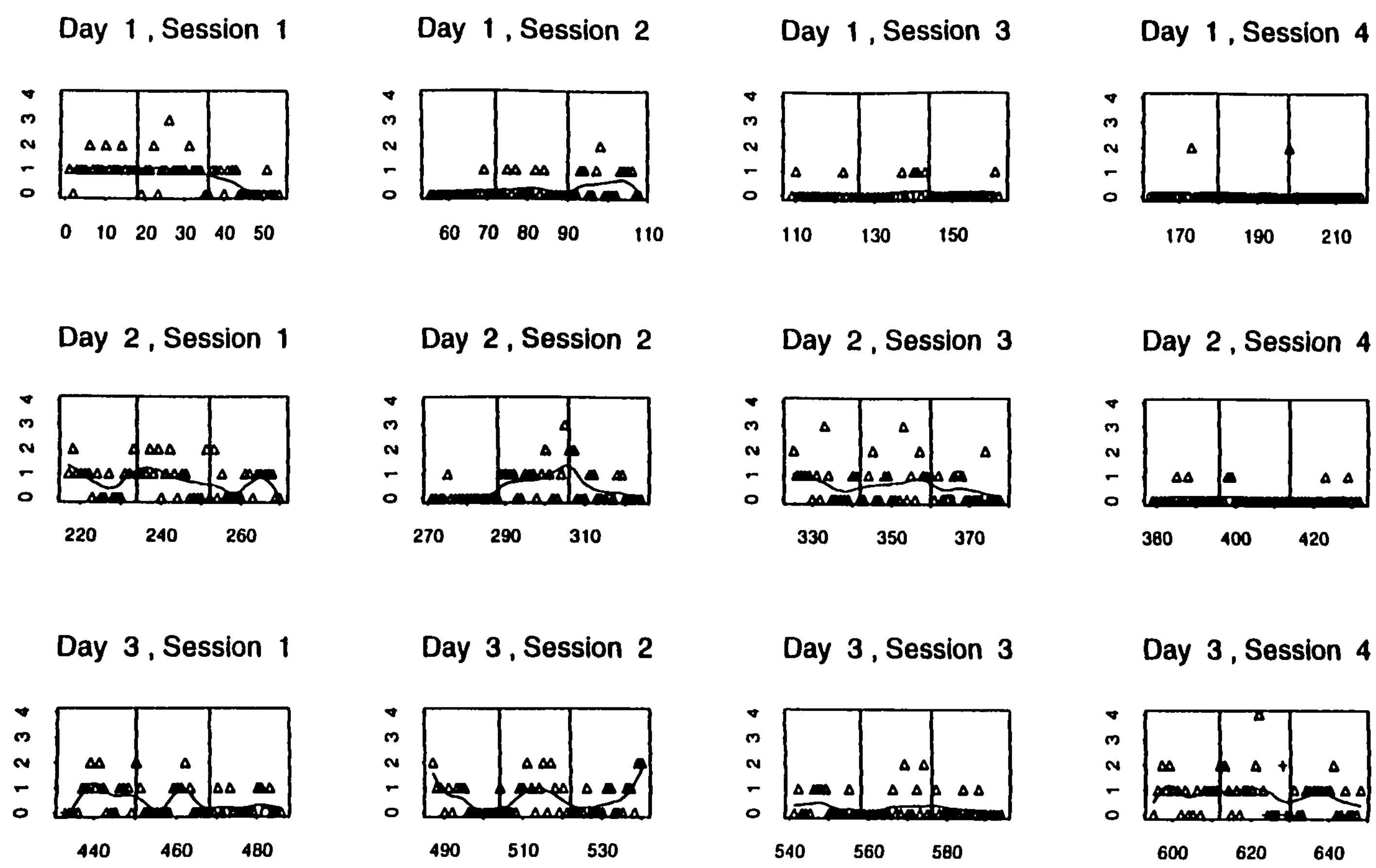

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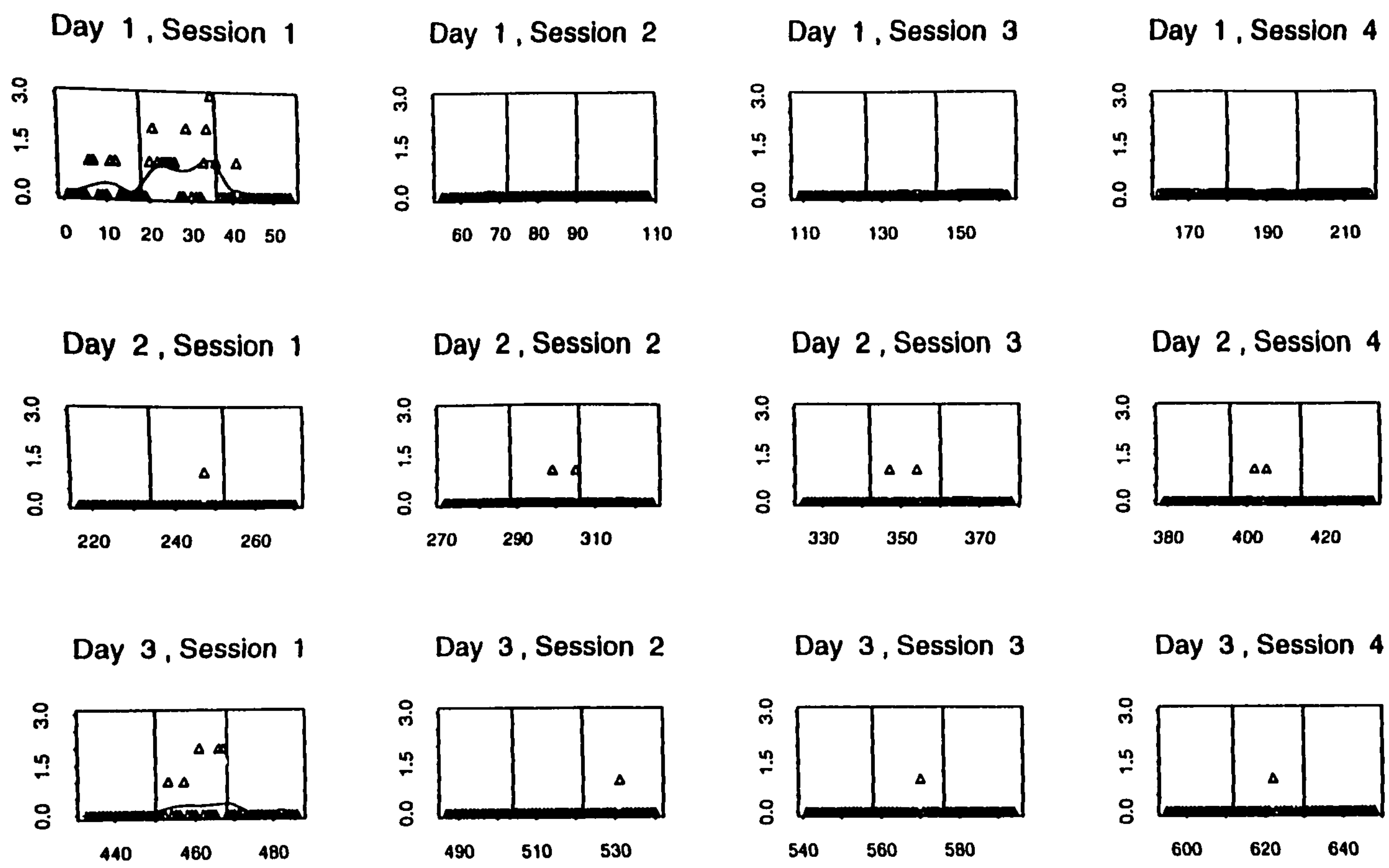

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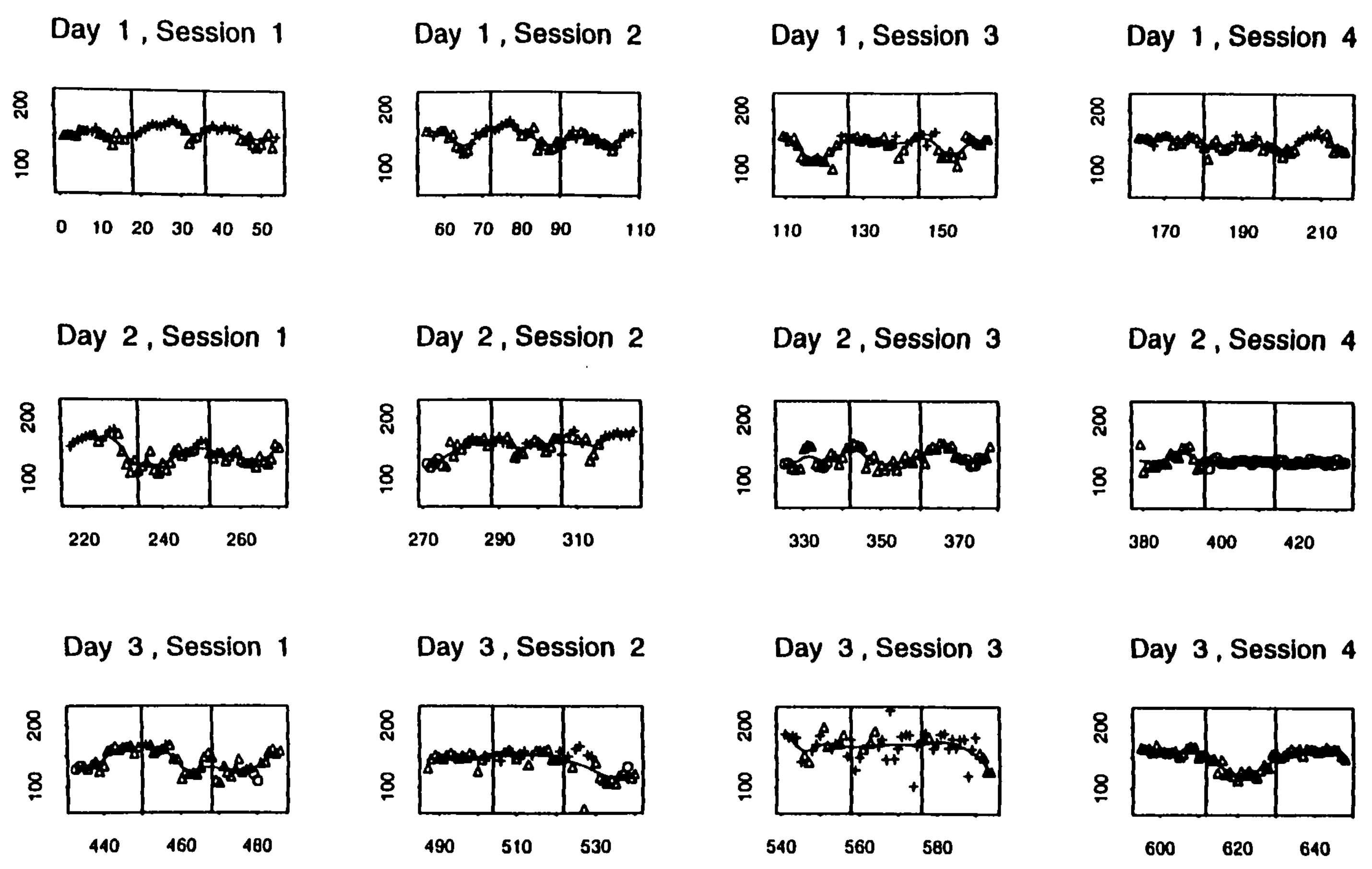

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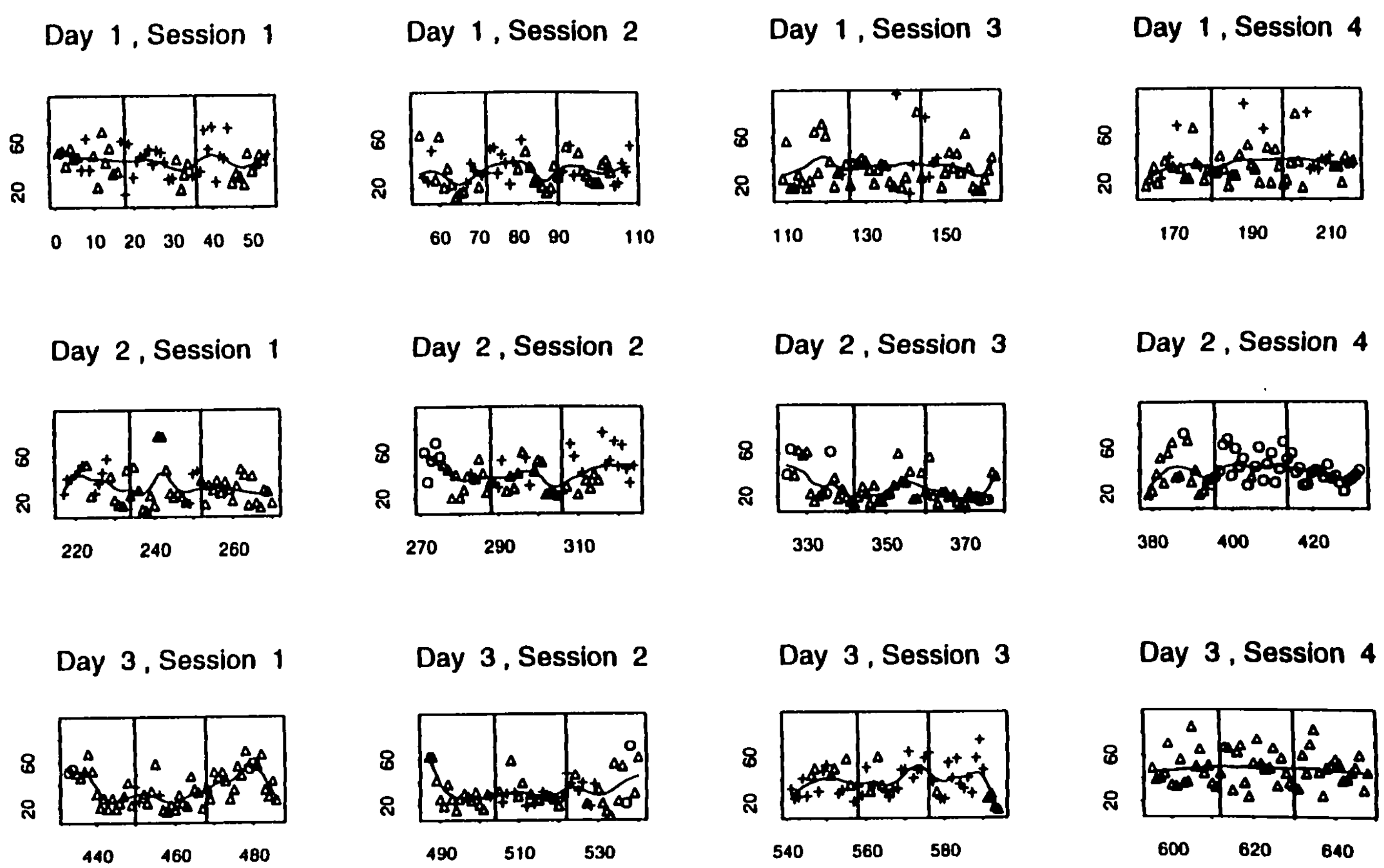

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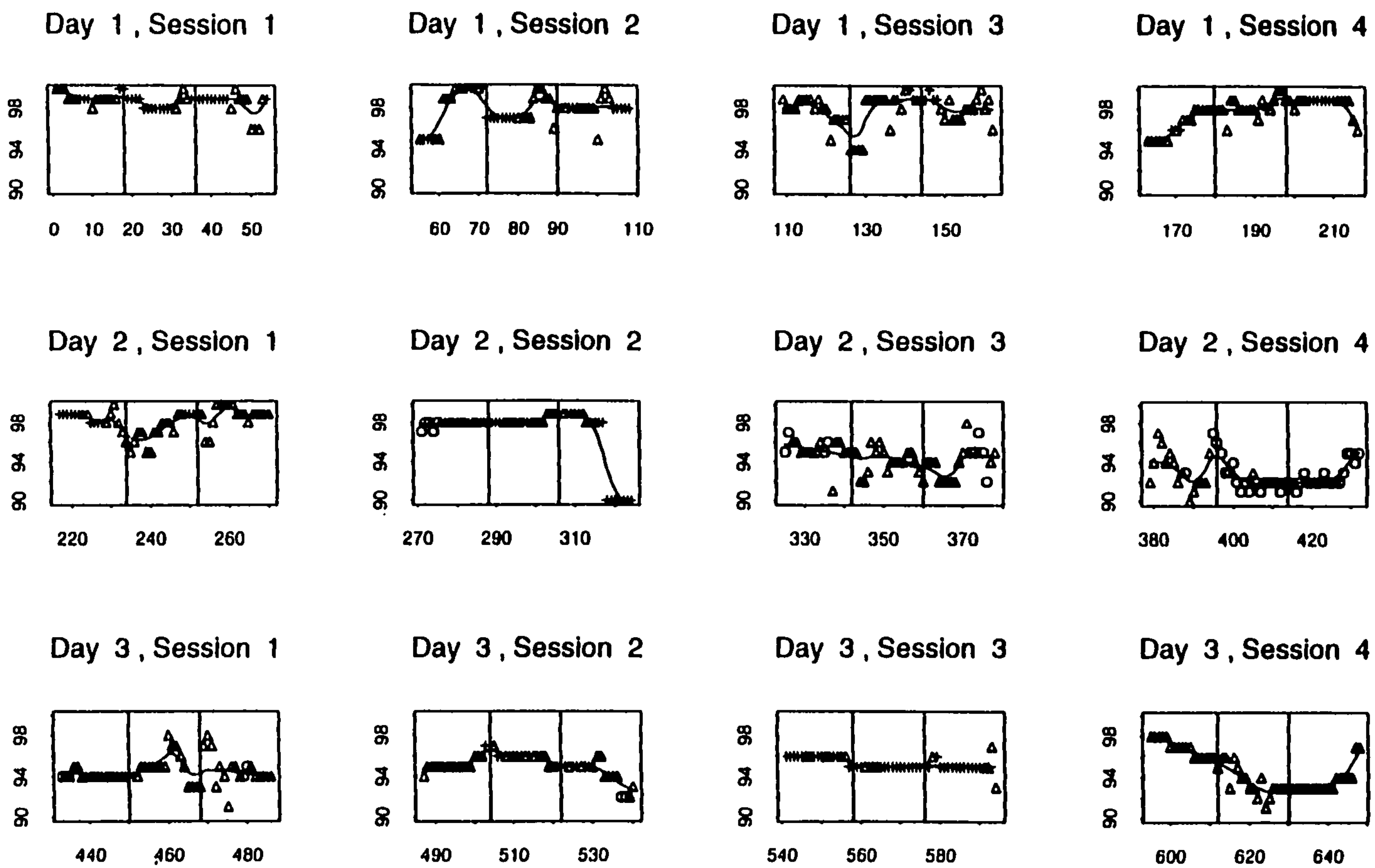

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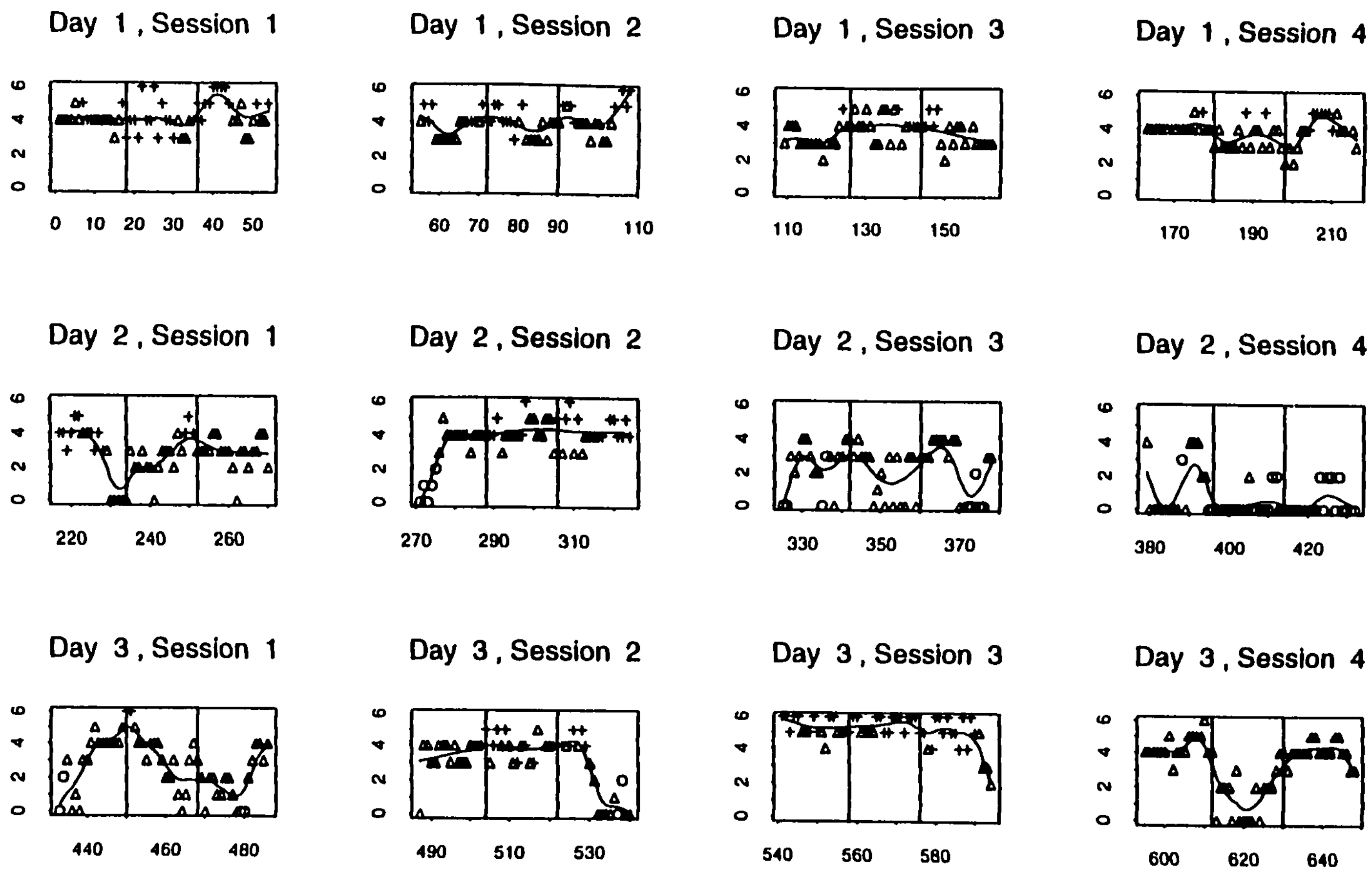

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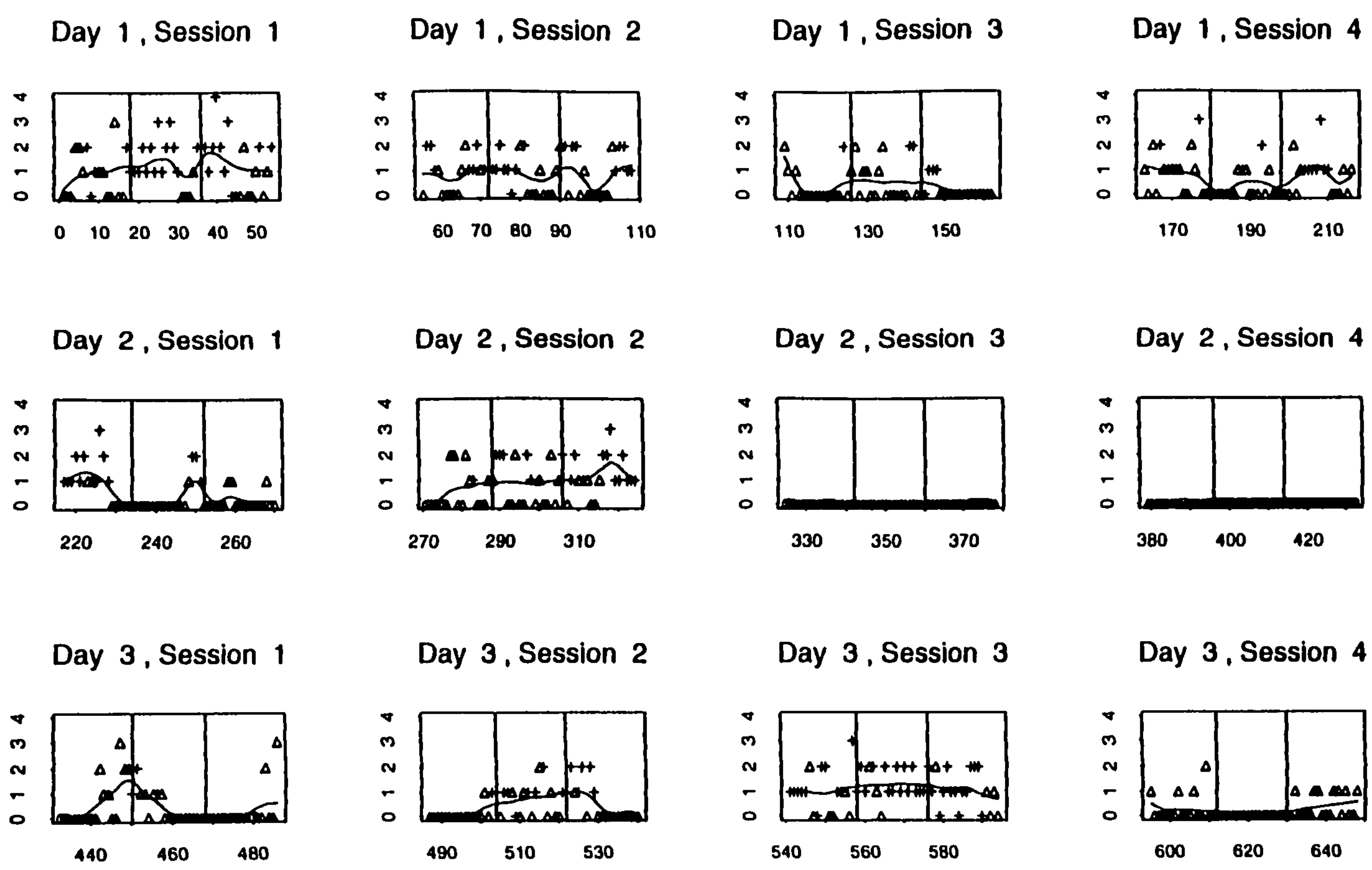

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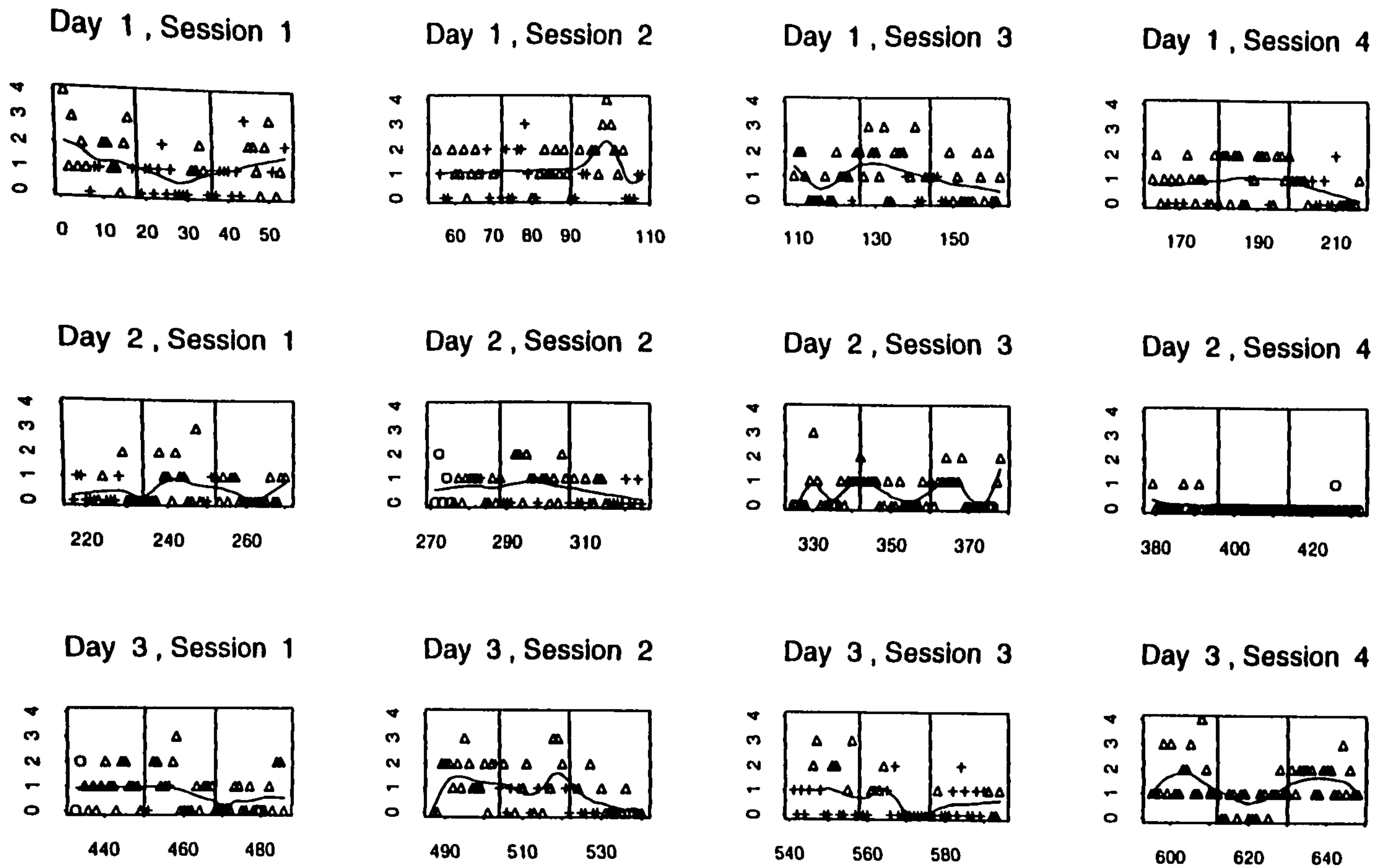

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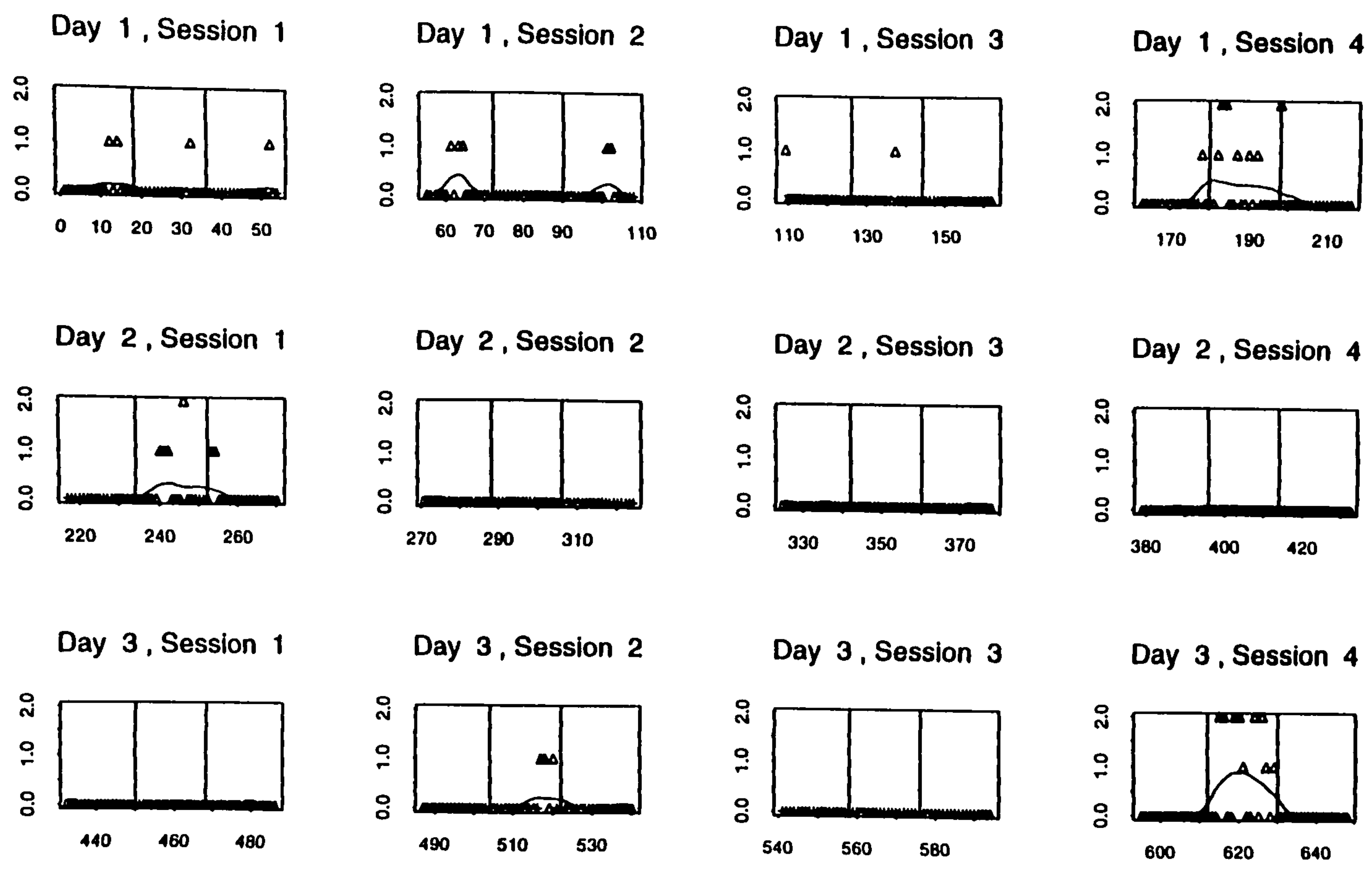

Biographical Note

Name:	Maryann Bozzette
Birth:	October 18, 1951 Dansville, New York
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Degrees:	Bachelor of Science in Nursing D'Youville College, 1973 Master of Science in Nursing University of Washington, 1984 Doctor of Philosophy in Nursing Science University of Washington, 1997