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I am submitting herewith a dissertation written by Theresa Lyla Tucker entitled "Psychophysiological Correlates in Children with Conduct Disorders." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

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We have read this dissertation and recommend its acceptance:

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Associate Vice Chancellor
and Dean of the Graduate School

PSYCHOPHYSIOLOGICAL CORRELATES IN CHILDREN WITH CONDUCT DISORDERS

A Dissertation

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Degree

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Theresa Lyla Tucker

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DEDICATION

This dissertation is dedicated to Bruce Vogel, who planted the dream but died before it was ever acted upon, and to my grandfather, Clyde Lyon, whose presence in my life is sorely missed.

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ABSTRACT

Thirty-two children with conduct disorder (CD) and forty-four children without conduct disorder (control group) were compared on impulsivity, heart rate variability, heart rate, forehead EMG, electrodermal activity, systolic and diastolic blood pressure during rest periods, playing a video game, and a paper-and-pencil task (AD). The control group was more impulsive than the CD group on the Arrow Dot test. There were no differences between the groups on the Matching Familiar Figures Test. This is discussed in terms of task complexity. Heart rate variability was less for both the video game and rest than recovery for the CD group. Baseline heart rate was lower than all other conditions for the sample. Heart rate in the CD group was greater during the video game than the following rest period. Forehead EMG was greater in the CD group than the control group and greater during the video game for both groups. Electrodermal activity was greater at baseline than any other interval for the sample. Electrodermal activity was greater for the video game than the following rest period or the AD task. The a priori prediction that the CD group baseline electrodermal activity would be lower than the control group's was supported. Each task raised

systolic blood pressure above baseline measures for the sample. The video game increased systolic blood pressure over rest, AD task, and recovery. The control group's diastolic blood pressure was greater during the video game than AD task and rest. The CD group's heart rate variability reactivity was greater than the control group. The video game elicited more electrodermal, systolic blood pressure, and diastolic blood pressure reactivity than the AD task for the sample. The control group's diastolic blood pressure reactivity was greater to the video game than AD task. The CD group demonstrated more heart rate recovery than the control group and more recovery from the video game than from AD task. The sample showed more electrodermal and diastolic blood pressure recovery after the video game than AD task. These results are discussed in terms of parasympathetic nervous system mediation and coupling of physiological systems.

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CHAPTER 1

INTRODUCTION AND PURPOSE

Conduct disorder is a category of disturbed behavior found in children under the age of 18 years, which includes a wide variety of antisocial acts, such as aggressive behavior, theft, vandalism, lying, firesetting, and running away (Kazdin, 1987). Kazdin (1989) has defined conduct disorder as "...a pattern of antisocial behavior, when there is significant impairment in every day functioning at home or school, or when the behaviors are regarded as unmanageable by significant others." (p.2) Children with conduct disorders are at high risk for severe social/psychological dysfunction even when they are not later diagnosed as having an antisocial personality disorder (Kazdin, 1987). The etiology of a conduct disorder seems to encompass several factors. It is likely that infant temperament plays a role in the development of conduct disorder in some children. If the infant is irritable, hard to handle, or has high intensity reactions to new stimuli, he may be more likely to develop behavior problems (Earls, 1981). How this is related to the development of conduct disorders is speculative. It is postulated that the infant's temperament may influence the parent-child interaction which is a factor found to influence the child's risk of developing a conduct disorder (Patterson and Reid, 1984).

Parent-child interactions, regardless of infant temperament, are also an important factor in the behaviors that a child learns. Antisocial behavior, as well as prosocial behavior, can be learned from parent-child interactions. For example, parent-child interactions can provide reinforcement for aggressive behavior. When a parent-child conflict escalates and ends with the child getting what he wants, his aggressive behavior is reinforced by the parents' capitulation. Furthermore, if the parents' behavior toward the child is inconsistent and unpredictable, the child's instigation of parent-child coercive interchanges may be an attempt to obtain predictability since these interchanges are highly stable in sequence and outcome (Wahler and Dumas, 1985). The predictablility of parental behavior is thought to provide a sense of security or stability for the child. In a family where positive and negative reinforcement is non-contingent or follows no discernible rule, the predictability of a coercive exchange may be the only situation where the rules are readily discernible to the child. Thus, escalating aggressive behavior can be seen as a way of organizing a chaotic situation (Wahler and Dumas, 1985).

The possibility of a genetic factor in the likelihood of developing antisocial behavior is supported also. It is well-known that conduct disorder/antisocial behavior is likely to be a cross-generational attribute (Wahler and

Dumas, 1985). The likelihood of a child developing a conduct disorder is greater if the parent has a history of antisocial or criminal behavior (Loeber and Dishion, 1983). Whether the likelihood is environmentally influenced or genetically transmitted is difficult to separate.

The studies that best explore the possibility of a genetic factor involvement in the development of antisocial behavior are the twin studies. The results of Christiansen (1977) and Lange (as cited by Mednick and Hutchings, 1978) indicate a higher likelihood that if one twin engages in antisocial behavior, then the other will also. In fact, the strongest support for a genetic component to antisocial behavior is the higher concordance of monozygotic twins as opposed to dyzygotic twins (Mednick and Hutchings,1978).

Whether antisocial behavior is learned or genetically transmitted, its devastating cost to the individual and society is unchallenged. Many studies have examined adults and adolescents who have been hospitalized or incarcerated to determine correlates of antisocial behavior. The following review is an examination of two types of correlates of antisocial behavior. The first section reviews studies of the physiological correlates of antisocial behavior in adults, adolescents, and children. The second reviews studies of impulsivity in conduct-disordered children. Following the literature review, a

rationale for further investigation of physiological measures and impulsivity in school age children with conduct disorders is presented.

CHAPTER 2

LITERATURE REVIEW

Physiological Responses of Individuals with Antisocial Personalities

Electrodermal activity in adults. Physiological studies of adults with antisocial personalities support the hypotheses that there are physiological differences between antisocial personalities and other groups, that these differences are stable over time, and that the degree of antisocial behavior is correlated with differences in physiological responses. The studies of adults and adolescents who exhibit antisocial behavior have variously classified these people as psychopaths, sociopaths, antisocial personalities, criminals, and delinquents. For the purposes of this paper each study will be reviewed in the original authors' terms with the understanding that each classification denotes antisocial behavior. The physiological findings in the adult antisocial personality studies are commonly measured by electrodermal activity (EDA), such as galvanic skin resistance (GSR) or skin conductance (SC), and heart rate (HR). The SC studies will be reviewed first, then studies measuring multiple physiological indices.

In a classic study by Lykken (1957), primary

sociopaths, those lacking normal emotional reactivity, neurotic sociopaths, those not meeting requirements of primary sociopathy, and a group of normal university and high school students were compared on two self-report anxiety scales loading on a neurotic factor, one self-report anxiety scale without a neurotic factor, a personality inventory, and galvanic skin resistance (GSR) in a learning task . The manifest task was to learn a maze in 20 trials. There were four possible alternatives at each choice point in the maze, one of the incorrect alternatives was followed by the subject receiving a shock. The latent task was learning to avoid the shock. Two buzzers were used as the conditioned stimulus and to test generalization.

Lykken's (1957) results indicated that neurotic sociopaths scored significantly higher on anxiety measures than the normal group. On the measure of anxiety without neurotic loading, the primary sociopath group scored significantly less anxious than the normals and the neurotic sociopaths. As expected, both groups of sociopaths had higher scores on the personality measure of psychopathic deviance than the normal group (Lykken, 1957). In the avoidance learning task, the primary sociopaths and the neurotic sociopaths were significantly less GSR-reactive and were less GSR-conditionable than the normal group. The neurotic sociopaths had significantly higher GSR than the primary sociopath at the end of the extinction trials

(Lykken, 1957). Lykken (1957) concluded that primary sociopaths have abnormally low levels of anxiety, defective avoidance learning, and decreased ability to condition (learn) the anxiety response.

In a study using the same maze learning and latent avoidance learning tasks, Schmauk (1970) studied effects of physical punishment (shock), tangible punishment (loss of money), and social punishment (experimenter saying "wrong") on primary and neurotic sociopaths and a normal control group. He also obtained three self-report ratings of anxiety, one prior to starting the learning task, after the first trial through the maze, and after the last (tenth) trial through the maze. Schmauk's results indicated that primary sociopaths scored significantly below normal group in anticipatory arousal (as measured by SC), subjective anxiety, and avoidance learning. When looking at the results of the three punishment contingencies, primary sociopaths show significant increases in anticipatory SC, subjective anxiety, and avoidance learning when the punishment was loss of money. The three subject groups demonstrated no significant differences in basal SC or in SC reactivity (Schmauk, 1970).

Combining the three groups led to a significant finding of greater SC reactivity under the shock condition than under the other two punishments. The results of autonomic anticipatory SC activity indicated that when the punishment

conditions were combined, the normal group had significantly greater SC activity than either of the sociopathic groups. The normal group's anticipatory SC was significantly greater than the primary sociopath group under physical and social punishment and significantly greater than the neurotic sociopath group under social punishment (Schmauk, 1970). An interesting conclusion from the results of the self-reported anxiety and avoidance learning in Schmauk's study was that primary sociopaths' avoidance learning became better with their increases in anxiety labeling, while the neurotic psychopaths' avoidance learning became worse as their subjective anxiety increased.

In a sample of uninstitutionalized sociopaths compared to college students, Sutker (1970) found no significant differences in baseline GSR between groups. The sociopathic group had no significant increases in EDA during anticipation of shock to another person; however, the sociopathic group had a significantly greater increase in magnitude of GSR at the time of shock when compared to the student group. The pattern of GSR for these two groups was different. The student group showed increased GSR in anticipation of the proposed shock to another as well as at the time of shock while the sociopathic group's GSR increased only at the time of shock, albeit significantly more in magnitude during the first trial (Sutker, 1970). While not significant, the sociopathic group had a tendency

to respond less to shock in later trials (Sutker, 1970). Sutker explains her results by proposing that sociopaths are deficient in their ability to experience anticipation, tend to overreact to aversiveness initially, and rapidly lose interest in what they initially found exciting.

Using numbers on a memory drum with shock given at the number eight, Hare (1965) studied the EDA of a psychopathic criminal group, a nonpsychopathic criminal group, and a noncriminal group. The first trial did not involve shock but the remaining five trials were with shock. In contrast to Sutker's 1970 findings, Hare (1965) found a significantly lower resting EDA in the psychopathic group as compared to the other two groups, significantly smaller EDA to the shock in the psychopathic group when compared to the nonpsychopathic group, and no difference in EDA to shock between the psychopathic group and the noncriminal group. In line with Sutker's findings, the psychopathic group demonstrated significantly smaller anticipatory EDA than either of the other groups (Hare, 1965).

Studying GSR conditionability, Hare (1965a) used a tone (CS), shock (UCS), and two different tones as generalization stimuli to determine responsiveness between a group of psychopathic prisoners and a group of nonpsychopathic prisoners. The paradigm was ten CS tones alone, ten CS-UCS trials, a presentation of the CS tone, and a presentation of the generalization tones. The nonpsychopathic group's GSR

was significantly more conditioned than the psychopathic group's and the magnitude of response decreased significantly to the generalization-stimulus-two in the psychopathic group (Hare, 1965a). The results support the hypotheses that psychopaths condition the fear response significantly more slowly than the nonpsychopaths and there is less generalization of the conditioned fear response by psychopaths (Hare, 1965a).

In a normal population of eighty young adults, Waid (1976) separated three groups according to their socialization scale score into high, medium, and low socialization. After thirty pairings of a warning signal with a noxious tone, he found that the low socialization group had significantly smaller SC responses than the high socialization group (Waid, 1976).

Waid, Orne, and Wilson (1979) studied socialization, awareness, and electrodermal response to deception in college males. This normal sample was divided into highly and lowly socialized groups, according to scores on a socialization scale. Both groups were monitored physiologically in an unaware and an aware condition; half of each group were to deceive an experimenter, the other half were to make truthful denials. The awareness or lack of awareness of physiological monitoring had no significant effect on SC responsiveness. The highly socialized deceptive group had significantly greater SC response to

critical, self-disclosing questions than to noncritical questions, their SC response to critical questions was significantly larger than those of the lowly socialized, deceptive group or the highly socialized, truthful group, and they gave significantly greater SC responses to noncritical questions than the lowly socialized, deceptive group (Waid et al., 1979). The lowly socialized group showed no significant difference in SC response between deception and truthful denial. The lowly socialized, deceptive group responded no differently to critical or noncritical questions than the lowly socialized group making truthful denials (Waid et al., 1979).

In another sample using a population of students, Hare (1965b) found a difference in SC between those scoring high and low on a scale of psychopathic deviance in anticipation of shock. Those scoring high on psychopathic deviance responded later, more slowly, and to a lesser degree than those scoring low on psychopathic deviance. The baseline SC was not significantly different between the groups (Hare, 1965b). Hare suggests that the emotional effect is not evident in those scoring highly on psychopathic deviance until punishment is imminent (Hare, 1965b).

Quay (1965) in an early review article presents evidence of psychopaths having more rapid SC recovery times as well as lower basal reactivity in contrast to some later results. Quay (1965) concludes that, because of lower basal

reactivity or an increased rate of adaptation, the psychopath can be seen as "stimulus seeking" in an attempt to ameliorate his sensory deprivation condition.

The SC recovery time of male criminals was examined with self-report measures of socialization, impulsivity, empathy, and neuroticism (Levander, Schalling, Lidberg, Bartfai, and Lidberg, 1980). The recovery time measure was computed as 50% recovery before the next response. The subjects were given a rest period followed by twenty-one tones and a final rest period. The subjects rating low in socialization and high in impulsivity had the longest recovery time and showed the least spontaneous fluctuations in SC during the recovery time (Levander et al., 1980). Recovery to the first stimulus was not significantly different from the mean recovery time for the low socialization group. Levander et al. (1980) suggest that a central process could account for the longer recovery in psychopathic subjects; psychopathic subjects may use a "sensory-gating" system that reduces the excitatory influence on the central nervous system (Levander et al., 1980).

Electrodermal activity in adolescents. Studies examining adolescents' electrodermal responses have also found differences between sociopathic groups and others. Fox and Lippert (1963) studied a group of juveniles with sociopathic personality disturbance and a group of juveniles with

inadequate personality diagnoses from a juvenile court detention center (ages unspecified), measuring ten minutes of EDA. Their results indicated low levels of anxiety for the sociopathic group and high levels for the inadequate personality group. The diagnoses were assessed by psychiatric and psychological evaluations. The inadequate personality had a significantly greater frequency of spontaneous SC activity but, as in much of the adult literature, there was no significant difference between the groups for basal SC (Fox and Lippert, 1963).

Supporting the above results, in a more complex design, Lippert and Senter (1966) measured GSR in adolescents with sociopathic personality or adjustment reaction from a detention center. The procedure after an adaptation period was a ten minute rest period, a ten minute visual and auditory stimulation period, a ten minute anticipating shock period, and a ten minute recovery period. The sociopathic group had significantly lower spontaneous SC fluctuations and this rate was not altered by shock anticipation. The adjustment reaction group had a drop in GSR when anticipating shock which none in the sociopathic group exhibited (Lippert and Senter, 1966). The base level GSR and elicited GSR were not significantly different between the two groups. During the recovery period, the mean number of GSR-active intervals were significantly lower for the sociopathic group than both its own pre-stimulation rest

period and the adjustment reaction group's recovery period (Lippert and Senter, 1966). Lippert and Senter (1966) suggest that sociopaths' electrodermal system responds only to concrete external events and electrodermal arousal associated with emotions occurs at a lower level than in other populations.

Grouping institutionalized adolescents from a 10-item antisocial personality scale as high, medium, or low, Siddle, Mednick, Nicol, and Foggitt (1976) focused on electrodermal recovery time. The stimulus in this study was a randomly presented tone. The recovery rate was one-half of the response amplitude divided by the half-recovery time. The half-recovery time was the time from peak response amplitude to half-response amplitude (Siddle et al., 1976). The results demonstrated that the recovery measures could significantly differentiate the groups. The high and medium antisocial groups had significantly slower recovery rates and half-time recovery time than the low antisocial group (Siddle et al., 1976).

In a regular school population, adolescent males were grouped from self- and teacher-report of socialization into undersocialized and socialized (Raines and Venables, 1981). Both the socialized and undersocialized groups were then divided into high and low socioeconomic status according to their parents' occupation. Skin conductance was measured during a rest period and a series of tones. The high SES

undersocialized group demonstrated significantly poorer SC conditioning than the other groups while the low SES undersocialized group demonstrated an easily conditioned skin response. Raine and Venables (1981) suggest that low SES adolescents are more likely to come from an environment where they are socialized (conditioned) into antisocial habits, whereas, adolescents from high SES who exhibit antisocial behavior may do so more from a biological factor's influence.

In a further look at the same sample, Raine and Venables (1984) found SC orienting responses to the first tone not significantly related to the measures of antisocial behavior. When dividing the sample above and below the mean to determine prosocial from antisocial groups, the results report significant findings that the categorical SC nonresponders belong to the antisocial group. However, Raine and Venables (1984) point out that 78% of the antisocial group were electrodermally responsive. Therefore, with three identified groups, antisocial nonresponders, antisocial responders, and prosocials, scores on sensation seeking, social withdrawal/disturbed relationships, and anxiety were examined. The results indicate that antisocial responders score significantly higher than prosocials on sensation seeking; antisocial nonresponders score significantly higher than responders or prosocials on the withdrawal/disturbed relationship index

(Raine and Venables, 1984). Raine and Venables (1984) suggest that there is a subgroup of schizoid antisocials who are autonomicallly underaroused.

In a prospective study, EDA was measured in a conditioning paradigm prior to any asocial behavior and again at age 20 years when the group was divided into delinquents and nondelinquents according to criminal records (Loeb and Mednick, 1977). The basal EDA levels were nonsignificant with a trend of delinquents having lower initial levels. The delinquent group was significantly less electrodermally responsive than nondelinquents. The nondelinquent group significantly reduced the amplitude of electrodermal response over trials while the delinquent group tended to stop responding. Loeb and Mednick (1977) note however that the delinquent group's amplitude was extremely low. During the recovery phase the delinquent group was significantly slower to recover than the nondelinquent group. The delinquent group demonstrated a significantly reduced amount of conditioning and reduced responding to the generalization stimulus (Loeb and Mednick, 1977).

Multiple physiological correlates. To this point, the focus has been on studies involving only SC measures of physiological activity. As Siddle (1977) has noted, there are some results that are quite consistently found. The

results suggest that people who engage in antisocial behavior have a slower SC recovery response, display a greater decrease in tonic electrodermal activity under monotonous stimulation, have smaller electrodermal responses in anticipation of noxious stimuli, and have fewer spontaneous SC fluctuations (Siddle, 1977).

The following literature review will not only continue examination of SC response results, but will examine studies using HR as well as multiple physiological indices. Hare (1972) used a prison population to form a group of psychopaths, a nonpsychopath group, and a mixed group in a study of SC, HR, respiration, eye blink, and electromyography (EMG). The subjects were given a rest period, injected with saline (unidentified to the subjects), another rest period, injected with adrenalin, then a recovery period. Tonic SC was significantly greater in the nonpsychopath group than either of the other groups, SC increases were significantly smaller in the psychopathic group than the nonpsychopathic group, and there were no significant differences between groups in tonic HR, respiration, eye blink, or EMG (Hare, 1972). Hare (1972) reports these results as being consistent with the hypothesis that psychopaths are electrodermally hyporeactive.

Schacter and Latane (1964) studied manifest task and latent (avoidance) learning using a criminal population

divided into sociopaths and nonsociopaths. They measured HR prior to an injection of either saline or adrenalin and again following the maze learning task. Under the saline condition the nonsociopaths significantly increased avoidance as compared to the sociopaths. However, under the adrenalin condition the sociopaths learned significantly better to avoid shock than the nonsociopaths (Schacter and Latane, 1964). Schacter and Latane (1964) report that the greater the sociopathy, the greater the HR. This is a result that Hare (1972) did not find using the same amount of adrenalin.

In another study that reported only HR results, Davies and Maliphant (1971) examined adolescent males from a boarding school. The teachers rated the students on "refractory" behavior and those were matched in a control group. Heart rate was measured 12 times at four different times during the day. The results indicated a significant difference in the base HR, with refractory subjects having a lower rate. The subjects were then allowed to earn money at a reaction time task. In the next step, the subjects were instructed that they would receive a shock for error or tardiness. The refractory group had briefer and significantly less elevation in HR than the control group under the threat of shock (Davies and Maliphant, 1971). In the final manipulation of this experiment, the threat of

shock was replaced by loss of the previously won money. The refractory group's HR reactivity was significantly lower than the control group's HR (Davies and Maliphant, 1971).

Raine and Venables (1984a) reported that their undersocialized adolescents had significantly lower HR levels than their prosocial group in an auditory conditioning paradigm. When they examined the relationship of lower HR and undersocialization according to social class, the only significant result was in the high social class (Raine and Venables, 1984a).

In a study of upper social class college students, Buikhuisen, Bontekoe, Plas-Korenhoff, and van Buuren (1984) examined self-report of crime two years before the study and during high school, self-report of conflict at home or school during childhood, ratings of father and mother, paper and pencil personality measures, and a medical interview. Skin conductance and HR were measured in response to sixteen tones followed by three aversive tones. The factors found to significantly discriminate offenders from non-offenders were negative parental home life, low anxiety, high impulsivity, hostility, and external locus of control. Buikhuisen et al. (1984) identified four factors according to the crimes committed and their concomittent psychophysiological components. The following is a brief summary of the four factors. Factor I involves a negative parental home; the subjects in this factor have a fast SC

recovery after an aversive stimulus. Factor II is a general propensity to criminal behavior; these subjects demonstrate a low HR and slow SC recovery after an aversive stimulus. Factor III is evasive crimes and the subjects are likely to be psychophysiologically hyporesponsive. Factor IV is crimes of violence; subjects in this group show a lack of anxiety as well as fast SC recovery after an aversive stimulus (Buikhuisen et al., 1984).

Hare (1982) counterbalanced an avoidable and unavoidable aversive tone in low, medium, and high psychopathic prisoners. The high psychopathic group had significantly smaller increases in nonspecific SC fluctuations than the low psychopathic group on the avoidable trial. The low psychopathic group had significantly more nonspecific SC fluctuations during the avoidable trial than the unavoidable trial. There were no differences between groups in physiological responses on the unavoidable trial (Hare, 1982). While none of the HR results reached significance,they tended in the predicted direction. Those high in psychopathy tended to have an increase in HR in anticipation of the sample tone and to decelerate on the unavoidable trial. The group low in psychopathy tended to accelerate HR at both of those times (Hare, 1982).

Subjects from a security hospital were designated primary psychopaths (high psychopathy and low anxiety), secondary psychopaths (high psychopathy and high anxiety),

and nonpsychopaths (Blackburn, 1979). Electrocortical activity (EEG), SC, HR, and systolic blood pressure (SBP) were measured during rest, auditory stimulation, cold pressor test, and recovery. During resting levels there was no difference between psychopathic groups and nonpsychopathic group in SC. Primary psychopaths were more cortically aroused and had significantly more spontaneous fluctuations of SC than secondary psychopaths (Blackburn, 1979).

During the tonic adaptation, the only significant result was the increase in EEG alpha level of primary over secondary psychopaths. There were no significant differences between psychopaths and nonpsychopaths during the reactivity phases. However, there was a tendency during the cold pressor test for the psychopaths to be more responsive in alpha change and less reactive in SC response than the nonpsychopaths (Blackburn, 1979). The habituation phase results indicate that primary psychopaths habituated significantly more in cardiac orienting response and less rapidly in SC than secondary psychopaths. Again, Blackburn (1979) found no differences in habituation between psychopaths and nonpsychopaths.

In a study of real-life stress, Levander, Lidberg, Schalling, and Lidberg (1979) measured SC, finger pulse volume, and HR in young adult prisoners two weeks, one week, and immediately before their court trial. The subjects were

placed in either the high psychopathy, low socialization, high impulsivity, low empathy group or the low psychopathy, high socialization, low impulsivity, high empathy group. The results of the physiological measures to tone stimuli indicate that the more psychopathic the subject, the lower level of autonomic activity regardless of the time of measurement. High scores on psychopathy and impulsivity were consistently related to large accelerative HR responses to the tone in the most stressful session. While not significant, many of the results were in the predicted direction. The trends were that the high psychopathic group had lower SC level, larger SC response levels and SC response means, fewer SC spontaneous fluctuations in all sessions, higher pulse volume levels, larger pulse volume response levels and means, more pulse volume spontaneous fluctuatuions in all sessions, lower HR level, larger peak-trough HR response levels, and more HR spontaneous fluctuations (Levander et al., 1979). The change score between sessions for physiological measures were significantly correlated although the measures in each session were correlated lowly and nonsignificantly. Levander et al. (1979) suggest that an external stressor may integrate the activation of different parts of the autonomic nervous system.

While Levander et al. (1979) found SC not to be

conditionable in their psychopathic subjects, Hare and Craigen (1974) found HR to be conditionable in their psychopathic prisoner sample. The psychopathic and non-psychopathic subjects were to choose the shock level administered to self and other, following a tone. Heart rate and SC were monitored. The major difference occurred on the first trial, where anticipatory HR of the psychopathic group markedly accelerated at the onset of the tone while the nonpsychopathic group's HR slightly decelerated. The second trial showed the reverse of the first trial and subsequent trials resulted in similar HR for both groups (Hare and Craigen, (1974). The psychopathic group gave small SC orienting responses and anticipatory responses to the tone preceding either shock to self or other when compared to the large SC responses of the nonpsychopathic group. Hare and Craigen (1974) interpret their results to mean that the small SC responses preceding aversive stimuli indicate an absence of fear arousal. The anticipatory cardiac acceleration reflects a process that reduces the impact of the situation (Hare and Craigen, 1974). These conclusions are in line with the later conclusions of Levander et al. (1979, 1980) of a sensory-gating mechanism that attenuates the aversive experience.

Hare and Quinn (1971) had observed the same SC results in a conditioning experiment. The psychopathic group had low tonic SC levels, lower nonspecific SC activity, smaller

SC responses to shock than the nonpsychopathic or mixed group. However, they found no significant differences in HR between psychopath, nonpsychopath, or mixed group (Hare and Quinn, 1971).

In an earlier conditioning study, Hare (1968) found primary psychopaths to have lower resting levels of SC and autonomic variability than nonpsychopathic prisoners. The primary and secondary psychopath groups tended to adapt to the conditions of the experiment in terms of SC to a greater extent than the nonpsychopath group. However, SC was found to habituate the same for all groups (Hare, 1968). The primary psychopath group was less responsive to the tones in either SC or HR. Cardiac deceleration and digital vasoconstriction habituated more slowly in primary psychopaths (Hare, 1968). The results were interpreted to support an autonomic, cortical, and sensory coupling (Hare, 1968).

Supporting the evidence of Hare and Craigen (1974) and Levander et al. (1979, 1980), Hare, Frazelle, and Cox (1978) found larger increases in HR and smaller increases in EDA in anticipation of an aversive noise from the psychopathic group. Hare et al. (1978) cite Obrist's (1976) active/passive coping theory when accounting for their results. They state that HR acceleration may indicate active attempts to cope with an aversive situation and EDA may indicate the success of these attempts (Hare et al., 1978).

Goldstein (1965) studied the relationship of muscle

tension, respiratory rate, HR, BP, and SC to psychiatric disorders. Acute psychotics, neurotics, character disorders (psychopaths and sociopaths), and normals completed two self-reports of anxiety and were monitored during a rest period and white noise. The results indicate that character disorders and normals have significantly less anxiety than psychotics or neurotics. Neither character disorders and normals nor psychotics and neurotics were significantly different in level of anxiety. The noise produced significant increases in all physiological responses except diastolic BP for all groups. Psychotics reacted with more intensity than all other groups and both normals and character disorder groups had highly similar low physiological responses (Goldstein, 1965). Most of the results were nonsignificant. When Goldstein (1965) controlled for anxiety, he found that depression and psychosis contributed to increased physiological arousal.

In the Mednick and Hutchings (1978) longitudinal study of 311 individuals (age unspecified), approximately ten years after the initial contact, 36 were found to have been convicted of crimes. The physiological indices showed that ten years earlier these individuals had a slower electrodermal recovery rate than the controls. The nine subjects clinically diagnosed as psychopathic had an even slower electrodermal recovery rate. These findings are consistent with those of other studies (Hare, Frazelle,

and Cox, 1978; Levander, Schalling, Lidberg, Bartfai, and Lidberg, 1980; Siddle, Mednick, Nichol, and Foggitt, 1978) finding slower electrodermal recovery rates in subjects classified as psychopathic, sociopathic, or antisocial.

Physiological studies have reported data which support a familial connection between electrodermal response levels and reactivity between fathers and sons who have antisocial behavior. Mednick and Hutchings (1978), in their review of studies of criminals vs non-criminals, found that the pattern of electrodermal response to a tone in children with criminal fathers resembles the pattern anticipated in their fathers. In further investigation of environmental versus genetic factors in criminal behavior, Mednick and Hutchings (1978) studied 94 father-son combinations which resulted in identification of four groups: criminal father-criminal son, criminal father-noncriminal son, noncriminal father-criminal son, and noncriminal father-noncriminal son. The results were reported in terms of which factors were involved in preventing the "like father, like son" hypothesis from being true. In the criminal father-non-criminal son group,the sons' IQ was significantly higher than in the other groups. These sons also had faster electrodermal recovery responses than the other groups. In the noncriminal father-criminal son group, the sons had the slowest skin-conductance recovery response of all four groups. Mednick and Hutchings (1978) report that these

findings suggest that both environmental and physiological factors play a role in the development of antisocial behavior.

While many of the results of physiological activity and antisocial behavior are conflicting, there are some definite trends. The most supported results are that SC spontaneous fluctuations are fewer for antisocial groups, SC recovery rates are longer, anticipatory SC level is lower, and HR is initially higher in antisocial groups.

Physiological Response in Conduct-Disordered Children

The research on physiological responses in children with conduct disorders is sparse. One study (Raine and Jones, 1987) of 40 behaviorally maladjusted males, age 7-15 years, included measures of behavior problems, personality, heart rate, and attention. Heart rate was measured after a personality questionnaire, after administration of a measure reflecting susceptibility to internal distraction, and after a four-choice reaction time task followed by two questionnaires relating to personality factors. Both conduct disorder and socialized aggression correlated significantly with lower heart rates, high impulsivity, high psychoticism, high lie scores, and more errors on the RT task. Conduct disorder alone was related to external locus of control, while attention problems, anxiety/withdrawal and motor excess, had greater HR variablity during the RT task

(Raine and Jones, 1987).

Schmidt, Solant, and Bridger (1985) studied electrodermal activity of 11 children with conduct disorder and 11 normal children during rest, moderate tone stimulation, and loud bell stimulation. The conduct disorder group showed a tendency toward lower electrodermal reactivity during the tone trials and significantly lower reactivity during the bell series than the control group. This study supports a similarity between the conduct disorders' and the antisocial personality disorders' electrodermal response to stimuli. However, Schmidt et al. (1985) did not find the resting electrodermal activity to be lower than the normal group.

A longitudinal study (Buikhuisen, Bontekoe, Plas-Korenhoff, and Meijo, 1988) of 11 to 13 year old boys assessed psychological, neurological, psychophysiological, medical, and sociofamilial indices and six and nine years later checked the Danish police records on these people. The 102 subjects who could be classified, either as non-offenders or multiple offenders, and who had gone through the earlier conditioning paradigm using auditory stimuli, were found to have significant differences. Lower verbal IQ, left-handedness, parental home (criminality of father, emotional stability of mother, deviance from two biological parents), higher percentage of slow alpha EEG waves, and SC rapid habituation were all related to delinquency

(Buikhuisen et al., 1988).

Venables (1987) cites a personal communication with B.C. Little that teacher-rated antisocial children at ages 9 and 11 years had lower HRs than those not rated antisocial. However, this was not true when these children were 7 years old (Venables, 1987).

In a study by Venables (1987), delinquency ratings were obtained 6 and 8 years after SC activity was measured. Parent-rated delinquency at age 11 years and teacher-rated delinquency at age 9 years were examined in conjunction with SC activity measured at age 3 years. Tonic, phasic, and recovery differences were reported. High social class, parent-rated delinquents had higher SC levels and increased nonspecific SC responses at age 3 years, during the tonic period of the study, than those rated nondelinquents at age three years. The low social class, parent-rated delinquents had significantly lower tonic SC levels than nondelinquents. In the teacher-rated delinquents, there were significantly fewer number of SC nonspecific responses than the nondelinquents in both social classes at age 3 years. The phasic SC activity of teacher-rated delinquents is also class specific. High social class delinquents had a higher amplitude response than nondelinquents at age 3 years. Low social class delinquents had lower amplitude response in the first orienting response of each series of tones. Skin conductance recovery findings indicate that parent-rated

aggressive 11 year olds had a significantly shorter half-recovery time at age 3 than children rated intermediate or nonaggressive (Venables, 1987).

Farrington (1988) also reports a longitudinal study that began when the sample was 8 years old and ended in 1980 when the youngest was 25 years 6 months. An in-depth and complex study, criminal records were checked as well as interviews and tests of the children, parental interviews, and teacher questionnaires completed about the children's behavior several times over several years. The psychophysiological measure reported was HR. The 32 subjects convicted of violent crimes had significantly lower pulse rates than the 252 unconvicted youths. Self-reported violence at ages 14 and 16 years was positively related to pulses rate (Farrington, 1988). Considering that other studies have shown little physiological arousal of antisocial groups when they lie, it is difficult to interpret exactly the self-report of violence and pulse rate data.

An argument for a separation of hyperactive and conduct problem samples is presented by Delamater and Lahey's (1985) study. Measuring SC during baseline, passive listening task, instructions, active listening task, and recovery, they found, with hyperactivity separated out, that children with lower SC levels rate higher on conduct

problems. Those high on conduct problems and low on tension/anxiety had smaller SC response amplitude than the low conduct problem and low tension/anxiety group. The hyperactive children with high conduct problem ratings had significantly lower tonic SC level than those hyperactive with low conduct problem ratings. Skin conductance level was significantly lower between baseline and recovery for the high conduct problem and high tension/anxiety group and the low conduct problem and low tension/anxiety group. Delamater and Lahey (1985) conclude that physiological differences previously attributed to hyperactivity may be correlates of conduct problems instead.

Another study (Wadsworth, 1976) involving 11 year old children, measured pulse rates while they anticipated, but did not know for certain, what was going to happen and then after a physical exam. At age 13 years, a self-rating inventory was completed and at age 16 years, a personality inventory. Court appearances or formal cautions from police between the ages of 8 and 21 years were then obtained. The results pertaining to delinquency and pulse rate indicated no significant differences between the first pulse rate and either delinquent or nondelinquent group. Within the group of offenders however, the first pulse rate for boys committing violent or sexual offenses was significantly lower (Wadsworth, 1976).

As presented, there are three studies (Delamater and

Lahey, 1985; Schmidt et al., 1985 and Raine and Jones, 1987) that measure physiological indices in school age children known to engage regularly in antisocial behavior or exhibit a behavior problem not attributable to hyperactivity. The other studies (Buikhuisen et al., 1988; Farrington, 1987; Venables, 1988; Venables, 1987; Wadsworth, 1976) measure physiological indices prior to asocial behavior. All these studies lend support to an hypothesis that there is a physiological similarity between childhood antisocial behavior and adult antisocial personality disorder. However, with so little data the findings must be considered tentative.

Impulsivity as a Component of Conduct Disorder

The reflective-impulsive continuum describes a range of cognitive styles with behavioral correlates (Kagan, Rosman, Day, Albert, and Phillip, 1964; Unruh and Gilliam, 1988). In their early studies of normal children, grades 1 - 4, which led to the development of the Matching Familiar Figures Test (MFFT), Kagan et al. (1964) defined reflection as "the consideration of alternative solution hypotheses (either classification or problem-solving sequences) when many alternatives are available simultaneously." (p. 33) The implication is that impulsive is the opposite of reflective. The face validity of impulsiveness in children with conduct disorders is apparent. However, as Unruh and

Gilliam (1988) note, there are very few studies which examine the relationship of impulsivity to conduct disorders. Many of the studies do not differentiate conduct disorder from other emotional disorders.

In a study of emotionally disturbed children matched on mental age and not differing on chronological age, Finch, Pezzuti, Montgomery, and Kemp (1974) examined 15 impulsives and 15 reflectives as determined by performance on the MFFT: high error score with short latency score were impulsives and low error score with long latency score were reflectives. Their sample was from a residential treatment center with a mean chronological age of about 12 years. The results indicate that the achievement test scores did not significantly differentiate the reflectives from the impulsives. However, the reflectives' grade placement was two grades higher, a significant difference, than the impulsives. When both groups were combined, the error scores were significantly negatively correlated with achievement scores and mental age (Finch et al., 1974). Within this emotionally disturbed population, there was no relationship between cognitive style and academic achievement within grade level.

Information-seeking questions were developmentally classified in a study of emotionally disturbed children, mean age 10.6 years (Finch and Montgomery, 1973). The children were grouped as reflective or impulsive on the

MFFT; the impulsives made significantly more errors on the MFFT than the reflectives. The reflectives used more developmentally-advanced, information-seeking questions. It is interesting to note that in the table Finch and Montgomery (1973) presented, the diagnostic categories were not found to correspond with either reflective or impulsive. However, the two children with hyperkinetic reaction were classified as impulsive but the one child with unsocialized aggressive reaction of childhood was classified reflective. Admitting to the many problems involved with comparisons between groups in separate studies, Finch and Montgomery (1973) do so by concluding that emotionally-disturbed children are more impulsive than normal children.

Using the same treatment center sample as in the above study, teacher-rated locus of conflict for the impulsive and reflective children was obtained (Montgomery and Finch, 1975). The conflict between the impulses and inhibition is highly controlled in internalization, while externalization deals with conflict between the child's behaviors and reaction of others which is acted out in the environment (Montgomery and Finch, 1975). The impulsives were significantly more external in locus of conflict and reflectives more internal in locus of conflict (Montgomery and Finch, 1975).

Finch and Nelson (1976) studied reflection-impulsivity in emotionally disturbed children, mean age 11.32 years, in

a residential treatment center using the MFFT and a parent-rated behavior questionnaire. They found that the impulsive group were described as: reporting that others blamed them unfairly, threatening self-harm, hitting and bullying others, and playing excessively roughly (Finch and Nelson, 1976). Finch and Nelson (1976) conclude that impulsives are minimally concerned about making mistakes and do not fear violating social norms, while reflectives are overly concerned about making mistakes and adults' disapproval of them.

In a study that examined reflection-impulsivity in behavior-disordered children and a normal control sample, Brown and Quay (1977) administered the MFFT to 15 normal fifth graders, 15 normal 10th graders, eight behavior-disordered fifth graders, and 15 behavior-disordered 10th graders. The behavior-disordered sample were from a residential treatment center and their psychiatrists described them as hyperactive and "acting out." The results indicated no significant differences between the normal samples and the behavior-disordered sample in reflection-impulsivity. Among the behavior-disordered group, the older group was significantly more reflective on the error measure than the younger behavior-disordered group. The older behavior-disordered group had equivalent error scores to both normal groups. The young behavior-disordered group was significantly more impulsive than the young normal group on

the error measure. There was no significant difference on the latency measure between any of the groups. The MFFT error negatively correlated with IQ score (Brown and Quay, 1977). Brown and Quay (1977) suggest that there is a lag in the development of reflectiveness in behavior-disordered children.

From a normal sample of children, mean age 13.68 years, Eysenck (1981) used self-report measures,a personality questionnaire, an impulsiveness scale, and an antisocial behavior scale to study impulsiveness and antisocial behavior. The results in this early adolescent group were a significant correlation between antisocial behavior and impulsivity and psychoticism. There was a weak relationship between antisocial behavior and venturesomeness and low empathy (Eysenck, 1981).

Using 27 students labeled emotionally disturbed/behavior-disordered by a school district using state-mandated criteria and 27 normal peers matched on sex, race, and age, Unruh and Gilliam (1988) measured impulsivity by the MFFT and measured IQ. The sample formed four groups: 9 and 13 year old normal and emotionally disturbed/behavior disordered children. The results indicate that between the normal and emotionally disturbed/behavior disordered groups there were no significant differences in either response time or error score on the MFFT. The younger and older groups did not differ on either response time or error

score. However, the younger and older emotionally disturbed/behavior disordered groups differed significantly on both time and error scores; the older, the longer the response time and the fewer the errors. This was reported as support for a developmental trend for the emotionally disturbed/behavior disordered group but not for the normal group (Unruh and Gilliam, 1988). This also supports the results of Brown and Quay (1977) of a reflective developmental process in behavior-disordered children but not normals. Brown and Quay (1977) however did not find a significant difference in latency score on the MFFT as Unruh and Gilliam (1988) did.

The dearth of studies examining the relationship of impulsivity and conduct disorders is apparent. Most of the studies (Brown and Quay, 1977; Finch and Montgomery, 1973; Finch and Nelson, 1976; Finch, Pezzuti, Montgomery, and Kemp, 1974; Montogomery and Finch, 1975; Unruh and Gilliam, 1988) include many other emotional and behavioral problems in their samples besides the antisocial behavior of those with conduct disorders. The most significant results of these studies are that there appears to be a delay in reflectivity development in behavior-disordered children that is not found in normals, that impulsivity does not correlate with academic achievement, that impulsives externalize their impulse conflicts, and that impulsives ask developmentally-less-advanced information seeking questions

than reflectives.

The one study (Eysenck, 1981) that examined only antisocial behavior and impulsivity used a normal population of early adolescents and found a significant correlation between impulsivity and antisocial behavior. It is important that the face validity of the relationship between impulsivity and conduct disorder be examined further.

The Cardiac-Somatic Hypothesis

The cardiac-somatic hypothesis initially meant that cardiac function, as measured by heart rate (HR), was directly coupled with muscle activity. Therefore, any change in somatic activity or cardiac rate will be reflected in the other variable (Obrist, Webb, Sutterer, and Howard, 1970). The importance of this lies in the implication that cardiac rate and somatic activity are processes integrated by the central nervous system. In a reaction time (RT) task study of 62 college males, using pharmocological cardiac blockade in half the subjects, Obrist et al. (1970) measured HR, eye blink/movement, and chin EMG. While their results indicated that blocking the cardiac response did not influence performance of the RT task, the results did indicate a direct relationship between RT and the magnitude of cardiac deceleration in the subjects not pharmacologically blocked. These results support the

cardiac-somatic hypothesis in which change in HR and EMG magnitude are manifestations of a central nervous sysem integrating process.

In an active avoidance versus passive exposure study, Lovallo, Wilson, Pincomb, Edwards, and Brackett (1985) report significant differences in HR, muscle tension, systolic blood pressure, and diastolic blood pressure between the two conditions. The active avoidance group had higher HR, more muscle tension, higher systolic and diastolic blood pressure. Both conditions resulted in significant changes in neuroendocrine, lipid, and cardiovascular measures from baseline values. The authors state that since peripheral resistance changes were the same for both conditions, the adjustment of muscle tension and cardiovascular activity in the active coping condition are expressions of central nervous system integration (Lovello et al., 1985).

A developmental study (Obrist, Howard, Sutterer, Hennis, and Murrell, 1973) testing the cardiac-somatic hypothesis during a simple RT task presented data on 4,5,8, ten year olds, and adults. Heart rate, chin EMG, eye movement, general activity, and respiration were measured during baseline condition and RT task. The results indicated that age was related to levels of HR and somatic activity except eye blink frequency, with higher HR and more activity from younger subjects. With age correction, HR and general activity were significantly

related. Of interest and supporting the cardiac-somatic hypothesis across age groups, is that at all age levels there was a significant decrease in both somatic activity and HR in anticipation of or coincident with the execution of the RT task. These authors report that at all age levels studied, HR and somatic activity directionally mirrored each other during the task (Obrist et al., 1973).

O'Neill and Hinton (1979) also found cardiac-somatic coupling in 30 hospitalized psychopathic or schizophrenic males but only on the second day of testing. They suggest that anxiety may have prevented the coupling on day one.

While the cardiac-somatic hypothesis is well supported, it has not gone unchallenged. A study of cardiac and somatic response patterns during a RT task in 25 fifth grade boys and 25 college males (Lawler, Obrist, and Lawler, 1976) suggests an independence of cardiac and somatic activity that evolves into a coupling of cardiac and relevant somatic activity through a two-process model. The two-process model suggests that there is an initial generalized response which reduces competing responses and is characterized by an overall decrease in somatic activity. The model suggests that the second part occurs over a longer period of time. It is characterized by a localized process by which changes in task-relevant somatic activity and HR become coupled. The data of Lawler, Obrist, and Lawler (1976) fit this model well. The forearm EMG pattern (task-relevant somatic

activity) evolved to become the same as the HR pattern over trials. The chin EMG pattern's (task-irrelevent somatic activity) final form was the same as on trial one, showing only a decrease in magnitude as HR and relevent EMG stabilized (Lawler, Obrist, and Lawler, 1976).

Haagh and Brunia (1984), using an auditory warning signal as well as auditory reaction signal, found that task irrelevant somatic activity did not differ from baseline and that cardiac deceleration in the foreperiod is not related to somatic inhibition. The first finding is in line with that in the previously mentioned study by Lawler, Obrist, and Lawler (1976). The latter finding of Haagh and Brunia (1984) that cardiac deceleration is not related to task relevant or irrelevant somatic activity is in opposition to the cardiac-somatic hypothesis.

In a study of operantly conditioned heart rate, using shock avoidance and using varying degrees of instruction to control somatic activity, Obrist, Galosy, Lawler, Gaebelein, Howard, and Shanks (1975) report that reinforcement of decreased HR influenced both somatic activity and HR in a common direction. However, in all groups the change in HR in the first trial block was an accelaration regardless of the presence or abscence of the contingency, the direction for which the contingency was to effect, or the extent somatic activity was controlled. The authors conclude that the initial HR acceleration indicates that the effect is

independent of somatic activity. Again, the study supports and challenges the cardiac-somatic hypothesis. An important conclusion from this study is that HR is related to somatic activity when the alterations in HR are vagally (parasympathetic innervation) mediated.

In a 1976 article reviewing cardiovascular-behavioral interaction, Obrist (1976) discusses the cardiac-somatic hypothesis in terms of active and passive coping. He describes passive coping, e.g. classical aversive conditioning, in terms of vagal control of HR. In a classical conditioning paradigm the HR changes during the task can be attributed to either vagal excitation (causing HR deceleration) or vagal withdrawal (causing HR acceleration) (Obrist, 1976). In passive coping situations somatic activity and HR are coupled (Obrist,1976).

Obrist (1976) continues by describing active coping, e.g. shock avoidance, in terms of sympathetic control of HR which leads to directional independence of cardiac and somatic activity. In a signalled RT study (Obrist, Lawler, Howard, Smithson, Martin, and Manning, 1974) where the subjects could avoid shock by responding quickly, sympathetic blockade was pharmocologically obtained in one group while the other group was sympathetically intact. The results clearly show HR activity to be similar in both groups except for the recovery time where the intact group continues to show HR acceleration and the blocked group

shows HR deceleration. In this same study (Obrist et al., 1974), the three measures of somatic activity have a pattern consistent with the HR pattern of the blocked sympathetic group. The conclusion drawn from this study is that active coping is more likely to initiate and perpetuate sympathetic influence on the heart.

In a study that further differentiates the function of the autonomic system on HR, Pollak and Obrist (1988) pharmacologically blocked either sympathetic cardiac innervation or vagal innervation. When compared to the autonomically intact control group, both treatment groups showed a significantly greater decrease in mean HR between the somatomotor (handgrip) task I and II. The decrease in HR between RT task I and II was significant only for the sympathetically blocked group. These results suggest that tasks involving somatomotor activation elicit HR increases through a combination of vagal activity withdrawal and sympathetic activity. Tasks involving active coping (RT) elicit HR increases through sympathetic activation (Pollak and Obrist, 1988).

In further support of the differential autonomic activity on HR, Langer, McCubbin, Stoney, Hutcheson, Charlton, and Obrist (1985) found that blocking sympathetic function diminished tachycardia during exercise and eliminated tachycardia during the RT task. Another result of this study was that the control group could be divided

into those most reactive and least reactive. Heart rate in the most reactive group was significantly increased from its resting level to reaction time response. Between the most reactive group and the least reactive group, HR acceleration was significantly greater for the most reactive group at RT response than for the least reactive group. During the physical exercise, HR measures were similar for both groups (Langer et al., 1985).

The cardiac-somatic hypothesis has stimulated research leading to differentiation of autonomic function on HR. The coupling of HR and muscle tension when parasympathetic innervation dominates cardiac activity and the uncoupling when sympathetic innervation dominates are important. In the research I propose the cardiac-somatic hypothesis should assist in explaining the HR and EMG results.

Pilot Study

The purpose of the pilot study was to measure physiological reactivity in children with conduct disorders. The hypothesis of this study was that school age children diagnosed as having conduct disorders would show increased heart rate and EMG to the initial task, maintain the increase over all conditions, and demonstrate no recovery to baseline. Blood pressure and heart rate variability were expected to demonstrate a pattern similar to that of heart

rate and EMG.

Method. Ten children aged 5-12 years, 6 males and 4 females, and their mothers were recruited from those in treatment at the Child Behavior Institute, University of Tennessee, Knoxville. These families were low SES and the referring problem was always the child's problem behavior. Each child was taken to a separate room where, after preparing the skin with isopropyl alcohol, the electrocardiogram (EKG) leads were placed on the upper abdomen and the ground lead placed slightly above the umbilicus. The electromyograph (EMG) leads were placed on the frontalis mucles above the eyebrows directly above the pupils as the child looked straight in front of him. The skin preparation for the EMG placement was the same as for the EKG placement. The blood pressure cuff was applied to the non-dominant arm for readings taken from the antecubital space (brachial artery). The EKG and EMG leads were connected to a Grass Model 7D polygraph with the appropriate preamplifier and driver amplifier. The blood pressure monitor was a Roche Arteriosonde, with remote control. The blood pressure measurement was manually triggered in the next room as soon as the cuff was in place to: a. obtain an initial value b. assure that the equipment was properly placed c. give the child a chance to experience the inflation/deflation of the cuff. The polygraph was started as the child was given a coloring book

or comic book for the ten minute baseline period. Blood pressure was taken at 3, 5, 7, and 9 minutes during baseline.

The tasks were the arrow-dot game and the peg game, Hi-Q. The mother, after being coached by one of the experimenters during the ten minute baseline, gave the child the instructions for the game. Each task was counterbalanced. Each task was 3 minutes long with a 3 minute rest period between the two tasks. Blood pressure was taken at 0 (the beginning of task I, II, and rest), 1, and 2 minutes. During the 5 minute recovery time the child was allowed to either color or read comic books. Blood pressure was taken at 1, 3, and 5 minutes.

While the child was being prepared for the collection of physiological data, the mother was in a separate room with another experimenter completing a brief family health questionaire, the Matthews Youth Test for Health (MYTH), and reviewing the instructions for the two tasks. The experimenter answered any questions the mother had about the study or the measures.

After the recovery period both the child and the mother were asked if they had any further questions. The mother was told what the child's heart rate and blood pressure were and usually a section of the polygraph output was shown to the child and the mother and each measure explained. They were thanked for their participation.

Results. Electromyographic activity was counted as the number of spikes per min above the mean motion. Heart rate variability (HRV) was counted as the maximum variability at baseline in the second 30 seconds. HRV was counted as the maximum variability during the first 30 seconds of instruction time I and II. Task I and II were measured in the third 30 seconds. Rest HRV was measured in the third 30 seconds, and recovery HRV was measured at about 2 minutes 30 seconds. Systolic and diastolic blood pressure were averaged for baseline, task I, rest, task II, and recovery. Heart rate was also averaged for each condition.

Means and standard deviations were calculated for the ten subjects' scores on heart rate, heart rate variability, and EMG during baseline, instruction I, task I, rest, instruction II, task II, and recovery (Table 1)*. Means and standard deviations for systolic and diastolic blood pressure were calculated for baseline, task I, rest, task II, and recovery (see Table 2).

Simple ANOVAs showed no significant differences for each of the measures between task I and task II. Systolic blood pressure at baseline was significantly ($p < .0019$ and $p < .0014$) lower than rest and recovery.

Diastolic blood pressure showed a significant difference ($p < .0487$) by t test between the resting mean and

*All tables and figures are in the appendix.

the recovery mean, the resting mean being lower.

Heart rate, heart rate variability, and EMG were not significantly different between baseline, rest, and recovery.

Discussion. There are some important findings in this pilot study. The first finding is best seen by plotting the means for EMG and heart rate (see Figure 1 and 2). As has been discussed, one would expect that EMG would correspond to heart rate, but as is shown in this sample, involvement in the task yields decreased EMG activity with increases in heart rate. It appears that the two systems represented by these indices are desynchronized. This (desynchronous electrodermal and heart rate pattern) has been found in populations with antisocial personality disorders (Blackburn, 1983; Hare, 1978). In Blackburn's review (1983) it is postulated that this pattern may attenuate further sensory input and thereby reduce the impact of an aversive situation.

The second important finding is the systolic blood pressure difference between baseline and both rest and recovery periods. This seems to support the hypothesis that this population would be slow to recover from stimulation. This is in line with the studies of older populations who have an antisocial personality disorder. In the older population, it is usually electrodermal activity that is used as the index of arousal. An explanation used by

Levander et al. (1980) is related to conditioning the fear response. Whereas a faster recovery time reduces autonomic arousal and results in a strong reinforcement for fast fear reduction and a successful avoidance response, a long recovery time will not provide this type of reinforcement.

As with the heart rate/EMG de-synchronization, perhaps the best explanation of the systolic blood pressure recovery findings, as well as the diastolic blood pressure recovery findings is one of gating. Perhaps it is the "gating out" suggested by Levander et al. (1980) that is occurring. Gating is a more centrally controlled process that essentially inhibits other sensory input when one type is at a certain (unspecified) level. In this way no other input will be fully experienced.

At one level this seems to be in contradiction to the "stimulus seeking" hypothesis which states that conduct disordered behaviors may be stimulus seeking activity to raise unusually low autonomic functioning. The resultant activity of the autonomic system reinforces the means, i.e. antisocial behavior, of attaining that increased activity. However, it may be that the stimulus seeking occurs to raise the low autonomic nervous system functioning in an attempt to mitigate the effects of an aversive state or situation. Stimulus seeking behavior may be used to stimulate the nervous system and thus, be used as a barrier to other

aversive stimulation. The idea leads to speculation that unsocialized behavior may be a means of blocking a subjectively more aversive state or situation.

Another concern regarding the blood pressure data is the possible health implications for this population. Because reactive systolic blood pressure is often linked to cardiovascular disease (Dembroski, Weiss, Shields, Haynes, and Feinleib, 1978), this population may be at risk health-wise. This is an aspect that could be studied further.

There are several problems with interpreting these data. One should keep in mind that this is an extremely small sample and besides replication, a comparison group would add much to the conclusions that could be drawn from the data. Another problem is with the sample itself. There was no attempt to separate children with conduct disorders from those with hyperactivity. A larger, more differentiated sample would allow a greater degree of certainty in stating the conclusions. In short, the findings and the reconciliation of the findings are extremely tentative and require further study.

CHAPTER 3

RATIONALE AND HYPOTHESES

Based on the literature and the pilot study, the goal of the present study was to explore the relationship between impulsivity and HR, heart rate variablity (HRV), systolic and diastolic blood pressure (SBP, DBP), EMG, and EDA in school age children with and without conduct disorders. The hypotheses were:

1. Children with conduct disorders will be more impulsive than those without conduct disorders.

2. Children with conduct disorders will not show cardiac-somatic coupling.

3. Children with conduct disorders will have greater cardiac acceleratory reactivity to the initial task than those without conduct disorders.

4. Children with conduct disorders will maintain a greater HR throughout the experimental situation than those without conduct disorders after the initial acceleration.

5. Children with conduct disorders will have a greater SBP and DBP reactivity than those without conduct disorders.

6. Children with conduct disorders will show a longer recovery time for SBP and DBP than those without conduct disorders.

7. Children with conduct disorders will have smaller

EDA reactivity than those without conduct disorders.

8. Children with conduct disorders will have longer EDA recovery to baseline time than those without conduct disorders.

CHAPTER 4

METHODOLOGY

Subjects

A total of ninety children, including three from an outpatient treatment program for children with severe behavior problems, aged 6-12 years, and one parent each were recruited from subsidized housing complexes in Knox County, Tennessee. Two of the children refused to complete the study. The children were separated into those with and those without a conduct disorder according to a T score of 63 on the aggressive and/or delinquent scales of the Child Behavior Checklist-Revised (CBCL-R) (Achenbach and Edelbrock, 1983). The data of those children receiving a T score of 70 on the hyperactivity scale of the Child Behavior Checklist-Revised were not included in the analysis in an attempt to control for hyperactivity confounding the results. The exclusion of these data resulted in 44 subjects in the control group and 32 subjects in the conduct disorder group (CD group). Mean age for the CD group was 9 years with a standard deviation of 1.9; mean age for the control group was 8.8 years with a standard deviation of 1.7. There were 16 Black children and 16 Caucasian children in the CD group; 19 Black and 25 Caucasian children in the control group. There were 17 males and 15 females in the CD

group and 18 males and 26 females in the control group. The groups came from the same socioeconomic status as measured by the FSED. A letter was sent or given to the parent describing the study and inviting him/her and the child to participate. Their participation was limited only if the child had been diagnosed as having a hyperactive disorder. Such a case made them ineligible to participate. Informed consent was obtained from the parent and returned to the experimenter; an appointment was then made for the study. The child's informed consent was obtained at the time of his/her participation in the study.

Questionnaires

Each parent was given a questionnaire packet (see appendix A) including:

1. Family Socio-Economic Disadvantage Survey (FSED) which determined socio-economic status (SES).

2. CBCL-R which measures behavior problems and social competency under 2 factors, internalization and externalization. The scales that make up these factors are: schizoid or anxious, depressed, uncommunicative, obsessive, compulsive, somatic complaints, social withdrawal, hyperactive, aggressive, and delinquent.

The CBCL-R is an instrument that gives academic background information on the child and requires rating

behaviors and social competence of the child as 0, not true (as far as you know); 1, somewhat or sometimes true; or 2, very true or often true.

Auchenbach and Edelbrock (1983) cite the following reliabilities: The test-retest reliability for individual items at one-week intervals were in the .90's. The 3-month interval reliability was .838 for the behavior problems and .974 for social competence items (Auchenbach and Edelbrock, 1983). For scale scores and total problem and competence scores, the one-week test-retest reliability was .89. Outpatient scores over a 6-month period for both behavior problem and competence scores test-retest correlation were in the .60's (Auchenbach and Edelbrock, 1983).

Impulsivity Measures

Each child was asked to complete two measures of impulsivity in a counterbalanced manner:

1. The Matching Familiar Figures Test (MFFT) (Kagan, Rosman, Day, Albert, and Phillips, 1964) is an instrument often used to measure the cognitive components of reflection-impulsivity. The 12-item test involves selecting from a set of alternatives the figure that exactly matches the standard figure. Response time and errors are negatively correlated with a median of about -.48 (Messer, 1976) and yield a latency score and an error score.

However, the usual manner of identifying impulsives and reflectives is by median split where those scoring high on errors and low on latency of response are impulsive and those low on errors and high on latency of response are reflective. Internal consistency reliability for MFFT response time is .89 and .62 for errors (Block, Block, and Harrington, 1974).

2. The Arrow-Dot Test is a perceptual-motor task that was developed to measure the psychoanalytic concepts of impulse, ego, and superego. The subject is directed to draw the shortest line from an arrow to a dot given the barriers present. The impulse (I) score measures impulsive behavior, the ego (E) score measures the balance of impulsive versus inhibiting behavior, and the superego (S) score measures inhibiting behavior. Reliability of test scores by test-retest method were: I score= .63, E score= .82, S score= .42 (Dombrose and Slobin, 1958).

Apparatus

Heart rate and HRV were obtained from electrodes placed on the child's upper abdomen. The child's skin was prepared with isopropyl alcohol and standard electrodes with adhesive collars filled with electrolyte gel (Systematic) were applied to either side of the abdomen and one in the center as a ground.

Electromyography was obtained form the child's forehead. The site was prepared with isopropyl alcohol and 2 standard electrodes with adhesive collars filled with electrolyte gel were placed above the eyebrows. The child was asked to look forward so the electrodes could be place directly above the pupils.

Miniature electrodes with miniature adhesive collars filled with electrolyte gel measured electrodermal activity from the palmer surface of the non-dominant hand. Heart rate, HRV, EMG, and EDA leads were connected to a Grass Model 7D polygraph with the appropriate preamplifiers and drive amplifiers. After application of the electrodes, the polygraph ran continuously until the end of the experiment.

Blood pressure was recorded from a Roche 1216 Arteriosonde with remotely controlled cuff which inflated upon experimenter-given signal. The pressure is sensed through the motion of the artery wall, Doppler technique.

Procedure

The procedure involved a 10 minute baseline (BAS) period, instruction for task I, a 3 minute task I (TK1), a 3 minute rest (RST), instruction for task II, a 3 minute task II (TK2), and a 5 minute recovery (RCVRY) period. During baseline a video of a quiet, low-keyed storytelling was played. During rest and recovery, the child could color

from a book or read comics.

Baseline in this experiment began after all the leads were applied. Baseline was 10 minutes with blood pressure readings taken after the blood pressure cuff was applied (initial value), and at 3, 5, 7, and 9 minutes. During the 3 minute rest period, blood pressure was taken at 0, 1, and 2 minutes. During the 5 minute recovery period, blood pressure was taken at 1, 3, and 5 minutes.

The tasks for this study were playing the Nintendo video game, Super Mario Brothers/Duck Hunt, (copyright Nintendo, 1989) and the Arrow-Dot Test. Each task was 3 minutes long. Instructions were given prior to each task by the experimenter and the tasks were counterbalanced. Blood pressure was obtained at 0, 1, and 2 minutes of each task.

The parent was asked to complete the FSED and CBCL-R while the child was involved in the experiment if they were not completed prior to the child's arrival in the lab. The experimental situation included the child completing the MFFT prior to the application of the leads or following the removal of the leads.

Data Quantification

The physiological data are quantified in the following manner. Electrodermal activity was counted as the number of spontaneous responses per minute. Electromyography activity was counted as the number of spikes per min above the mean

motion. Heart rate variability was counted as the maximum variability in each of the following periods: at baseline in the second 30 seconds, the first 30 seconds of instruction time I and II, the third 30 seconds in tasks I and II, the third 30 seconds during rest, and at 2 minutes 30 seconds into recovery. Systolic and diastolic blood pressure were averaged for baseline, task I,rest, task II, and recovery. Heart rate was also averaged for each condition.

The impulsivity measures were quantified in the following manner. The MFFT was scored for initial response time for the 12 items and then averaged to give a mean response latency score. The error score on the MFFT is calculated as the total number of errors made.

The second measure of impulsivity is the Arrow-Dot Test. The scores obtained are termed impulsive (I), ego or measure of realistic functioning (E), and superego or unnecessary restraint or inhibition (S) (Dombrose and Slobin, 1958). Each of the 20 problems is scored as either I, E, or S. Those with high I scores and low S scores are classified as impulsive.

The parent-completed information includes the FSED and

the CBCL-R. The FSED indicates low SES if the parent endorses four of the six statements. The CBCL-R is scored for each statement as 0, 1, or 2. Each score is then added to others that comprise one of the nine individual scales and converted to a T score. A T score of 70 is the 98th percentile and differentiates the clinical population from the norm (Auchenbach and Edelbrock, 1983). A T score of 63 on the scales Aggressive and/or Delinquent and a T score below 70 on the Hyperactive scale was used to differentiate conduct disordered children from their peers.

CHAPTER 5

RESULTS

The impulsivity data were subjected to t test analysis. A Groups x Repeated measures analysis of variance was performed on the physiological data. A Groups x Repeated measures analysis of covariance, with task I as the covariate, was performed on the change scores (task I minus rest and task II minus recovery) to determine recovery. A Groups x Repeated measures analysis of covariance, with baseline as the covariate, was performed on task I and task II to determine reactivity.

Impulsivity Measures

Impulsivity was measured by performance on the Arrow Dot Test and the Matching Familiar Figures Test. These measures yielded five pairs of scores between the two groups compared by t tests in Table 3. The Arrow Dot Test yielded an impulsive, an ego, and a superego score; the Matching Familiar Figures Test yielded a latency and an error score. The Arrow Dot Test (AD) scores were not significantly correlated to the Matching Familiar Figure Test scores for either group (see Table 4). T test results indicate non-significant differences between groups on these measures

except on the AD impulsive score. By one-tailed t test, the CD group scored lower ($p < .05$) on the AD impulse measure than the control group (table 3).

Physiological Measures

Means and standard deviations for heart rate variability, heart rate, forehead EMG, electrodermal activity, systolic blood pressure, and diastolic blood pressure are presented by groups in Table 5. The mean score of each measure is plotted for each group at baseline, during the video game, rest, during the arrow dot task, and recovery. These means are also presented in Figures 3-8. It should be noted that the video game and arrow dot task were counterbalanced; half the group received the video game first, half received the arrow dot task first.

Heart Rate Variability. Mean heart rate variability for both CD and control groups is plotted in Figure 3. While both groups appear to have similar means during baseline, the CD group decreases heart rate variability during the video game and rest, with escalating variability during the arrow dot task and recovery. The control group appears to maintain a fairly stable degree of heart rate variability over all conditions. They show a slight increase in variability from baseline to the video game, which is

maintained for the rest and arrow dot task, then a decrease to baseline values of heart rate variability during recovery.

Heart rate variability mean scores at baseline, video game, rest, arrow dot task, and recovery for the two groups were subjected to a repeated measures analysis of variance. A significant interaction effect of Groups x Repeated measures ($F(4,296) = 2.48$, $p < .05$) was found (see Table 6). Tukey B post hoc tests revealed a significant difference between the video game and recovery ($p < .05$) and between rest and recovery ($p < .05$, Tukey A and B) in the CD group. There were no group differences at single intervals; however, the control group did not change over time, while the CD group had early lower heart rate variablity followed by rebound during the arrow dot task and recovery periods (see Figure 3). Heart rate variability is significantly smaller during both the video game and rest than recovery for the CD group.

Heart Rate. Figure 4 shows mean heart rate for the two groups over baseline, video game, rest, arrow dot task, and recovery conditions. Baseline heart rate for the CD group is lower than the control group's heart rate. There is a large increase in heart rate for the CD group during the video game, a decrease at rest, followed by an increase during the arrow dot task (which is not of the magnitude of the initial increase), and a slight decrease during recovery

that does not return to baseline rates. The control group also demonstrates an initial increase in heart rate from baseline to the video game. However, they maintain the increase across rest, arrow dot task, and recovery. The control group does not show the lowering of heart rate during the rest and recovery intervals that the CD group does. Nor does the control group show as large an increase in heart rate to the video game as the CD group.

A Groups (2) x Repeated measures (5) analysis of variance on mean HR (see table 6) indicated a main effect of Repeated measures ($F(4,296)= 24.76$, $p < .001$) and an interaction effect of groups x repeated measures ($F(4,296)= 3.55$, $p < .008$). The post hoc tests indicated that baseline heart rate was significantly lower ($p < .01$) than for all other conditions for the total sample. In follow-up analysis of variance, the CD group showed baseline less than all other conditions ($p < .01$) and the video game greater than rest ($p < .01$) (see figure 4). The control group, in follow-up analysis of variance, showed only a difference between lower baseline than all other conditions ($p < .01$). While both groups began with lower baseline heart rates than at any other interval, the CD group showed significant recovery after the video game, but did not reach baseline level.

Forehead EMG. Mean forehead EMG for the two groups is presented in Figure 5. The CD group's EMG scores are

greater overall than the control group's. There is a marked decrease in forehead EMG activity to the video game for the CD group with a subsequent increase in activity during rest which is maintained during the arrow dot task and recovery. The control group also shows a decrease in forehead EMG from baseline to the video game with a subsequent increase at rest maintained during the arrow dot task and recovery. As shown in Figure 5, the increase in EMG after the video game does not return to the baseline value for the control group, but more nearly does for the CD group.

The repeated measures analysis of variance results for EMG measures (see Table 6) were significant for both main effects: Groups ($F(1,74) = 4.52$, $p < .04$) and Repeated measures ($F(4,296) = 2.57$, $p < .04$). As shown in F igure 5, EMG decreases during the video game for both groups, this was verified by Tukey A ($p < .05$)tests. Figure 5 also shows greater scores for the CD group than the control group at all points.

Figures 6 and 7 illustrate the relationship between heart rate and forehead EMG for the CD group (Figure 6) and the control group (Figure 7). It is notable that the patterns of heart rate and EMG for the CD group are mirror images of each other; when heart rate values increase, EMG values decrease; when heart rate values decrease, EMG values increase. In Figure 7, the control group shows a different pattern. Although heart rate and EMG values go in opposite

directions (heart rate increases and EMG decreases) during the video game, both continue from rest through recovery to maintain little change in heart rate or EMG values. The slight change in one is coincidant with that in the other.

Electrodermal Activity. Figure 8 shows the mean electrodermal activity for the two groups over baseline, video game, rest, arrow dot task, and recovery. The CD group shows a lower baseline electrodermal activity level than the control group. While their electrodermal activity does not change from baseline, there is a decrease in the level at the rest interval, with a very slight increase during the arrow dot task, and recovery intervals. The control group shows a decrease in electrodermal activity from baseline to the video game with a further decrease from the video game to rest. As with the CD group, there is a slight increase in electrodermal activity during the arrow dot task and recovery.

A repeated measures analysis of variance was performed with a between subjects factor of groups. The results (see Table 6) indicate main effects for both Groups ($F(1,74) = 4.71$, $p < .04$) and Repeated measures ($F(4,296) = 21.60$, $p < .001$). To follow-up the repeated measures main effect, Tukey A tests revealed that baseline values were greater than all other intervals ($p < .01$) and the video game values were greater than rest ($p < .01$) and greater than the arrow dot task values ($p < .01$). Because

Figure 6 shows baseline values to be the most discrepant between the groups, a repeated measures analysis of covariance with baseline covaried was performed. The results indicated only a significant main effect of Repeated measures ($F(3,222) = 9.10$, $p < .001$). Tukey A tests resulted in video game values greater than rest ($p < .01$), the arrow dot task ($p < .01$), and recovery ($p < .05$). The previous literature led to a priori prediction that the groups would differ at baseline with the control group being higher. To test that, t tests were performed that indicated that the CD group's baseline values were significantly lower than the control group ($p < .02$).

Systolic Blood Pressure. Systolic blood pressure means are plotted in Figure 9. The CD group's baseline systolic blood pressure is the same as the control group's baseline value. There is an increase in systolic blood pressure during the video game for both groups. Although the values vary across intervals, the control group's systolic blood pressure is greater at each point from the video game than the CD group. After the initial increase to the video game, both groups show a decrease in systolic blood pressure at rest. There is another increase during the arrow dot task for both groups, however, the increase is not as great as during the video game. Both groups decrease systolic blood pressure at recovery to the approximate value of the rest interval but

do not return to baseline values.

A repeated measures analysis of variance for systolic blood pressure means (see Table 6) yielded a main effect of Repeated measures ($F(4,296) = 20.51$, $p < .001$). Post hoc Tukey A tests revealed that each task raised systolic blood pressure above baseline levels ($p < .01$). In addition, the video game raised systolic blood pressure higher than rest ($p < .01$), the arrow dot task ($p < .01$), and recovery ($p < .01$). While Tukey A tests results indicate that the rest interval values did not recover to baseline ($p < .05$), it is only by Tukey B tests results that recovery interval values were also significantly different from baseline values ($p < .05$).

Diastolic Blood Pressure. Diastolic blood pressure means for both groups are shown in Figure 10. The CD group show a greater baseline diastolic blood pressure than the control group. The increases and decreases in diastolic blood pressure for the CD group across intervals is slight. There is an increase in diastolic blood pressure for the CD group during the video game followed by a decrease at the rest interval. A slightly greater increase from rest to the arrow dot task is followed by a slight decrease from the arrow dot task to recovery for the CD group. The control group shows a large increase in diastolic blood pressure from baseline to the video game, with a large decrease at the rest interval which continued to decrease during

during the arrow dot task. There seems to be a rebound at recovery to a value slightly higher than baseline for the control group. It is notable that while the CD group's diastolic blood pressure showed little variation across intervals, there was a great amount of variation across intervals for the control group.

A repeated measures analysis of variance on diastolic blood pressure (see Table 6) resulted in a main effect of Repeated measures ($F(4,296)= 2.45$, $p < .05$). The post hoc Tukey A tests resulted in no significant differences. Because a repeated measures main effect was obtained and post hoc testing revealed no significant results, a repeated measures analysis of variance on diastolic blood pressure was performed on each of the two groups separately. There were no significant results in the CD group ($F(4,124)= .29$, $p > .88$). The control group's results showed significant results ($F(4,172)= 3.15$, $p < .02$). Follow-up by Tukey A tests revealed that the video game raised diastolic blood pressure significantly over the arrow dot task ($p < .05$) (see Figure 8). And, Tukey B tests revealed that the video game raised diastolic blood pressure significantly over the rest interval values ($p < .05$).

Reactivity. A repeated measures analysis of covariance was performed (see Table 7) to determine group differences in reactivity to the video game and the arrow dot task. Baseline measures were covaried and analyses carried out to

determine whether one task or the other elicited greater response and/or whether there was a difference between the control and CD groups responses to either or both tasks.

The repeated measures analysis of covariance performed on heart rate variability resulted in no significant findings. A main effect of Groups ($F(1,73)= 7.80$, $p < .007$) resulted from the repeated measures analysis of covariance on heart rate. The CD group heart rate increased more (was more reactive) than the control group. Electromyographic reactivity did not show any significant group differences. For electrodermal activity, there was a main effect of task ($F(1,74)= 10.42$, $p < .002$); the video game elicited more electrodermal response than the arrow dot task for both groups. Systolic blood pressure reactivity also significantly differed between tasks ($F(1,74)= 8.16$, $p < .006$); the video game elicited a greater increase in systolic blood pressure than the arrow dot task. Similarly, diastolic blood pressure reactivity analysis yielded a significant difference between tasks ($F(1,74)= 4.96$, $p < .03$) with the video game response being greater than the arrow dot task response. This analysis also indicated an interaction effect ($F(1,74)=4.35$, $p < .04$); a repeated measures analysis of variance on diastolic blood pressure with the video game and the arrow dot task as the dependent variables demonstrated that the control group's diastolic blood pressure was significantly more reactive ($F(1,43)= 8.51$,

$p < .006$) to the video game than the arrow dot task. A separate repeated measures analysis of variance on diastolic blood pressure with the video game and the arrow dot task as the dependent variables for the CD group did not show a significant difference in diastolic blood pressure reactivity between tasks, i.e., the CD group did not reduce diastolic blood pressure to the arrow dot task, while the control group did.

Recovery. Recovery values were determined by change scores from the video game to rest (RCV1) and from the arrow dot task to recovery (RCV2); a repeated measures analysis of covariance was performed on the change scores with the video game values covaried (see Table 8).

Heart rate variability recovery was not significantly different between groups or for tasks. There was a main effect of Groups ($F(1,73) = 6.13$, $p < .02$) and an interaction effect ($F(1,74) = 4.18$, $p < .05$) for heart rate recovery. Larger change scores for the CD group were found therefore, more recovery occurred in the CD group than in the control group. This can be seen in Figure 4 by the decrease in means for the CD group from the video game to rest and the arrow dot task to recovery which is not evident for the control group means. Follow-up by *t* test showed that the groups were significantly different at RCV1 ($p < .005$). The CD group heart rate recovered more from the video game to rest than from the arrow dot task to recovery and more than

the control group heart rate recovered at either interval of recovery. Electromyographic recovery showed no significant differences. Electrodermal activity recovery analysis demonstrated a significant difference between tasks ($p < .0002$). There was more recovery for the sample after the video game than the arrow dot task. Systolic blood pressure recovery analysis indicated no significant differences. A main effect of interval ($F(1,74)= 7.72$, $p < .007$) and an interaction effect ($F(1,74)= 4.14$, $p < .05$) were found for diastolic blood pressure recovery. More recovery occurred after the video game than the arrow dot task for the sample. While the repeated measures analysis of covariance for diastolic blood pressure recovery indicated a significant interaction effect, *t* test results comparing the two groups on the two recovery measures revealed no significant differences. It would appear that the control group recovered more than the CD group in Figure 10, but by *t* test it is not significant.

CHAPTER VI

DISCUSSION

The two main concerns of this study were: 1) to determine if there were differences in impulsivity between children with conduct problems and those without conduct problems; and 2) to determine if there were differences in heart rate variablity, heart rate, forehead EMG, electrodermal activity, systolic blood pressure, and diastolic blood pressure between these two groups, while they were at rest and engaged in a task. The various hypotheses will be discussed in terms of the findings of this study and possible reasons for these results.

The first hypothesis was that the conduct disordered group would be more impulsive than the control group. The results indicate that the CD group is not more impulsive than the control group on the task that requires simple matching. On this measure, MFFT, they do not appear to make their choices more quickly, nor, to make more errors in their choice. These results are similar to the results of Unruh and Gilliam (1988), who found there was no difference between a group of emotionally disturbed/behaviorally disordered children and normal children on the MFFT. On the task which involves a psychomotor component, Arrow-Dot Test,

the control group were more impulsive than the CD group. Skrzypek (1964) studied a population of psychopathic and neurotic juvenile delinquents, where the two groups were differentiated on a behavioral checklist by aggressive acting-out behavior and withdrawn behavior respectively. The neurotic group prefered more simple and less novel tasks when they rated their anxiety as high. The psychopathic group showed no change in their preference for complexity and novelty, nor increase in anxiety to the increasingly difficult auditory discrimination task. These results, in concert with Jennings, Holmstrom, and Karp's (1986) results indicating that in normal undergraduates anxiety is negatively correlated with reflectivity, may assist in explaining the results of the impulsivity measures in this study. The control group may have experienced more anxiety on the more complex task where they were also being monitored by the physiological apparatus, resulting in more impulsive performance. It may be that the CD group, also under the same conditions as the control group, did not experience a change in anxiety which would result in a more impulsive score.

As indicated in Figure 6, the hypothesis that the CD group would not show cardiac-somatic coupling was supported. Elliott (1964) in a study of normal children (age 6 years) and adults, which he followed-up 2 years later (1966), found that heart rate and EMG were not correlated for the children

but demonstrated some changes toward the adult covariation of heart rate and EMG pattern at the follow-up. He reported that the adults showed significant correlation between heart rate and EMG both times (Elliott, 1966). He explained the difference in terms of maturation; the older one becomes then the more the two systems coincide in responding. In these terms, the CD group show an immature pattern of responding where heart rate and forehead EMG respond in opposite directions. The control group's pattern, while not exactly what would be expected in an adult group, is closer to the adult pattern than the CD group's pattern. In these respects, the CD group appear more immature than the control group. If it is accepted that maturity involves coupling of physiological measures, closer examination of the graphs demonstrate that the control group not only have closer cardiac-somatic coupling but also demonstrate a somatic-electrodermal coupling and a heart rate variability-systolic blood pressure coupling. The CD group demonstrate similar patterns in only the cardiac system, i.e., heart rate, heart rate variability, systolic blood pressure, and diastolic blood pressure. It may be that the control group have developed a different system for integration of various physiological systems. This argues for greater cental nervous system involvement for those in the control group.

Heart rate reactivity was the next aspect explored. While the hypothesis stated that the CD group would exhibit

more heart rate reactivity to the first task than the control group, they demonstrated more reactivity to both tasks than the control group. The reactivity differences contrast with Wadsworth's (1976) results of no heart rate differences between delinquent and nondelinquent groups of 11 year old children. However, the heart rate measures were collected differently, i.e., the pulse during anticipation and after a physical exam was taken only once at each of the two times in Wadsworth's study. Also, in Wadsworth's study the classification of subjects was according to police or court records.

Further examination of heart rate results demonstrated differences between conditions and in recovery for the CD group. Heart rate was greater during the video game than rest for the CD group. Heart rate recovery from the video game to rest was greater than recovery from the arrow-dot task to the recovery interval for the CD group, also. The hypothesis that the CD group's heart rate would elevate to the first task and remain at the elevated level throughout the experimental conditions was only partially supported. The CD group's heart rate did elevate to the first task but, the elevation was not maintained. Interestingly, it was the control group's heart rate that increased and was maintained at the increased level. Before leaving the heart rate data, it should be noted that the studies of children's heart rate and behavior problems (excluding hyperactivity) report

significant correlations between low heart rate and high behavior problems (Farrington, 1987; Raine and Jones, 1987; Venables, 1987; Wadsworth, 1976). Although there is no main effect of group in the heart rate results of this study, Figure 4 illustrates the lower heart rate of the CD group consistent with the results of the previously mentioned studies.

Although there were no hypotheses presented on heart rate variability responses, there were some significant results for the CD group. Within the CD group there were differences in heart rate variability between the video game and recovery, with the video game resulting in less variability. There was also less variability in the rest interval than recovery for the CD group. It appears that there is a rebound effect for the CD group, from baseline the heart rate variability decreases during the video game and rest to its lowest level and increases during the arrow-dot task and continues to increase during recovery. It may be that the CD group engages more in the video game, raising their heart rate which decreases their heart rate variability. The differences found may indicate a disengagement from (loss of interest in) the session.

There are two ways to explain the effect of the video game on heart rate and heart rate variability. It could be that the sympathetic nervous system activity was increased leading to the increase in heart rate, heart rate

reactivity, and the decrease in heart rate variability for the CD group but not the control group. The other possibility is that the parasympathetic nervous activity is withdrawn also leading to increased heart rate, heart rate reactivity, and decreased heart rate variability. For more clarification of the process, looking at the electrodermal activity, a measure of sympathetic function, will be helpful.

If the sympathetic nervous system is mediating the heart rate, heart rate reactivity, and heart rate variability responses then it would be expected that the pattern of electrodermal activity response would be similar to that of heart rate. The pattern would be one of increased heart rate, increased heart rate reactivity, increased electrodermal activity, and decreased heart rate variability. If the parasympathetic nervous system is mediating, then by its withdrawal, heart rate increases, heart rate reactivity increases, heart rate variability decreases, and electrodermal activity is not affected. Baseline or resting measures of a parasympathetically mediated group will show low heart rate, increased heart rate variability, and low electrodermal activity. Groups whose responses are mediated by different systems, will have different patterns. In Blackburn's (1983) review of the physiological literature in psychopathy, delinquency and crime, he states that there is consistent evidence that

psychopaths and nonpsychopaths do not differ on resting cardiac measures but that psychopaths do have lower resting electrodermal activity. This is also a result found in the current study. This study found that the patterns are different, as are the heart rate and EMG patterns. In line with the results of Venables (1988) and Delamater and Lahey (1985), the electrodermal activity results of this study support the hypothesis that the CD group has a lower level of arousal at baseline than the control group. Instead of electrodermal activity increasing during the video game, it decreased, albeit slightly, in the CD group. However, there was no significant difference in electrodermal reactivity between the groups as was hypothesized. The important point is that the indices that are expected to respond in the same direction do not in the CD group. At the interval when it is hypothesized that the CD group began disengaging from the session, during the arrow-dot task and recovery, the electrodermal increased very slightly. However, the hypothesis that the CD group would recover less was also not supported. The pattern is supportive of parasympathetic nervous system mediation of these physiological variables in the group with behavior problems.

The final hypotheses were related to systolic and diastolic blood pressure measures. It was predicted that the CD group would exhibit more reactivity and less recovery in both systolic and diastolic blood pressure. These

hypotheses were not supported. The control group had more diastolic responsivity to the video game than the arrow dot task.

Some of the differences found within the sample were expected. Heart rate and electrodermal activity results for the sample indicated that baseline was different from any other interval. For heart rate, baseline was less than the other intervals; for electrodermal, baseline was greater than any other interval. The sample began the session with relatively lower heart rates and higher electrodermal activity. For electrodermal activity, video game values were greater than rest or the arrow-dot task for the sample, demonstrating again that task's ability to elicit reactivity. Forehead EMG showed the same phenomenon with baseline showing less EMG activity than the video game produced. The sample's systolic blood pressure is highly sensitive to the video game also; the video game systolic blood pressure values are greater than any other interval. It appears that systolic blood pressure baseline values are less than rest and recovery values for the sample. Diastolic blood pressure is also greater during the video game than the arrow-dot task or rest for the sample. Electrodermal activity, systolic blood pressure, and diastolic blood pressure are more reactive to the video game than to the arrow-dot task in the measure of reactivity for the sample. Electrodermal activity and diastolic blood

pressure recover more from the video game than from the arrow-dot task for the sample probably because they are also more reactive to it.

The results do indicate that the CD group are not more impulsive, but are less electrodermally aroused initially, more cardiac reactive except for blood pressure measures, and have more muscle activity during rest than the control group. These are very much what might be expected in an older population who engage in antisocial behaviors. The theory that is being proposed to account for the results of this study is that children mature into an integration of physiological mechanisms. If a child has or develops a parasympathetic nervous system which mediates function more than the sympathetic nervous system, then that child will not experience anxiety in a manner that a majority of the population does. By not experiencing that anxiety, the fear response cannot be easily conditioned. Therefore, the child does not learn to avoid behaviors that are followed by punishment.

Another way of thinking about the underlying physiological differences may be that a child is predisposed to parasympathetic sensitivity and the central nervous system integration of the various systems does not develop as much in children with behavior problems. The result is the same; they do not learn avoidance behavior. There are, of course, individual differences in the degree to

which the physiological measures are or are not integrated. For some children, it may be that the maturation of the systems is a delay that is remedied with time; hence, those children that exhibit behavior problems in the early years that resolve over time. With variability in sympathetic and parasympathetic sensitivity some children may grow to be differentiated as primary or secondary psychopathic adults depending on the amount and type of integration. This is very speculative and would require longitudinal study of multiple physiological measures and behaviors from early childhood or infancy through adulthood.

Still, this does not completely answer why antisocial behavior is performed. Not learning fear or not experiencing anxiety does not have to be followed by the antisocial behavior although it deters some people from antisocial behavior. If the CD group has a lower baseline in electrodermal activity, which it does, then as Quay (1965) suggests there is the likelihood that there is the experience of sensory deprivation. With mild stimulation, as with the video game or the arrow-dot task, heart rate increased but not electrodermal activity. If, as Levander et al. (1980) suggest, an increase in heart rate acts as a screen or closing gate to further stimulation, then the nature of the stimulation to obtain an electrodermal response must be extremely novel, complex, or aversive (all

of which have been found to elicit an electrodermal response in antisocial adults). Learning can occur under these conditions for this population.

The challenges for the clinicians working with this population are multiple. By the time a psychologist sees the behavior problem child, the child will have years of being told he is bad, often several mental health system failures to help, and academic and social failures that contribute to low self-esteem and poor motivation. If under all of the above, there is a different physiological base, then a traditional insight therapy is not likely to help, at least initially. The difficulty is getting the child's attention, that is, in getting them to experience enough anxiety or stimulation to see the need to change or control their behavior. Probably an intrusive approach which entails a great deal of accountability by the child would be a start. The real challenge is to titrate the invasiveness which keeps the child involved in treatment and the support for any minor changes that the child makes. This style follows from the idea that the amount and type of physiological integration will differ with each child, making the amount of intrusiveness needed vary also.

Further study of multiple physiological systems' development and concurrent behavior is required to substantiate any conclusions of the interactions. Longitudinal study would greatly improve the accuracy of any

theories on the role that physiological development may play in observable behavior. Studies on the effects of learning to couple the divergent systems of those children with behavior problems would be an interesting follow-up to the study presented here.

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APPENDICES

FSED

Name of Family_____

Clinic File #_____

Place a checkmark after each of the following statements which accurately describe the family of the target child.

1. Gross family income for preceeding year $\leq$ 12,999.
2. Education of primary caregiver < high school grad. or G.E.D.
3. Primary caregiver is single, separated, divorced, or widowed OR has not been living with a common-law spouse for the past year.
4. Family resides in a "high crime" neighborhood.
5. Household includes $\geq$ 3 children (< 18 y.o.).
6. Target child or primary caregiver was referred for treatment by a human services agency.

Place total number of checkmarks in this box.

CHILD BEHAVIOR CHECKLIST FOR AGES 4-16

For office use only
ID #

CHILD'S NAME

SEX ☐ Boy ☐ Girl

AGE

RACE

TODAY'S DATE
Mo _____ Day _____ Yr _____

CHILD'S BIRTHDATE
Mo _____ Day _____ Yr _____

GRADE IN SCHOOL

PARENT'S TYPE OF WORK (Please be specific - for example: auto mechanic, 7th grade teacher, homemaker, aborer, lathe operator, shoe salesman, army sergeant, even if parent does not live with child.)

FATHER'S TYPE OF WORK _____

MOTHER'S TYPE OF WORK _____

THIS FORM FILLED OUT BY:

☐ Mother
☐ Father
☐ Other (Specify)

I. Please list the sports your child most likes to take part in. For example: swimming, baseball, skating, skate boarding, bike riding, fishing, etc.

☐ None

	Compared to other children of the same age, about how much time does he/she spend in each?				Compared to other children of the same age, how well does he/she do each one?			
	Don't Know	Less Than Average	Average	More Than Average	Don't Know	Below Average	Average	Above Average
a. _____	☐	☐	☐	☐	☐	☐	☐	☐
b. _____	☐	☐	☐	☐	☐	☐	☐	☐
c. _____	☐	☐	☐	☐	☐	☐	☐	☐

II. Please list your child's favorite hobbies, activities, and games, other than sports. For example: stamps, dolls, books, piano, crafts, singing, etc. (Do not include T.V.)

☐ None

	Compared to other children of the same age, about how much time does he/she spend in each?				Compared to other children of the same age, how well does he/she do each one?			
	Don't Know	Less Than Average	Average	More Than Average	Don't Know	Below Average	Average	Above Average
a. _____	☐	☐	☐	☐	☐	☐	☐	☐
b _____	☐	☐	☐	☐	☐	☐	☐	☐
c _____	☐	☐	☐	☐	☐	☐	☐	☐

III. Please list any organizations, clubs, teams, or groups your child belongs to.

☐ None

	Compared to other children of the same age, how active is he/she in each?			
	Don't Know	Less Active	Average	More Active
a _____	☐	☐	☐	☐
b _____	☐	☐	☐	☐
c _____	☐	☐	☐	☐

IV. Please list any jobs or chores your child has. For example: paper route, babysitting, making bed, etc.

☐ None

	Compared to other children of the same age, how well does he/she carry them out?			
	Don't Know	Below Average	Average	Above Average
a _____	☐	☐	☐	☐
b _____	☐	☐	☐	☐
c _____	☐	☐	☐	☐

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V. 1. About how many close friends does your child have? ☐ None ☐ 1 ☐ 2 or 3 ☐ 4 or more

2. About how many times a week does your child do things with them? ☐ less than 1 ☐ 1 or 2 ☐ 3 or more

VI. Compared to other children of his/her age, how well does your child:

	Worse	About the same	Better
a. Get along with his/her brothers & sisters?	☐	☐	☐
b. Get along with other children?	☐	☐	☐
c. Behave with his/her parents?	☐	☐	☐
d. Play and work by himself/herself?	☐	☐	☐

VII. 1. Current school performance—for children aged 6 and older:

☐ Does not go to school

	Failing	Below average	Average	Above average
a. Reading or English	☐	☐	☐	☐
b. Writing	☐	☐	☐	☐
c. Arithmetic or Math	☐	☐	☐	☐
d. Spelling	☐	☐	☐	☐
Other academic subjects—for example: history, science, foreign language, geography. e. _____	☐	☐	☐	☐
f. _____	☐	☐	☐	☐
g. _____	☐	☐	☐	☐

2. Is your child in a special class?

☐ No ☐ Yes—what kind?

3. Has your child ever repeated a grade?

☐ No ☐ Yes—grade and reason

4. Has your child had any academic or other problems in school?

☐ No ☐ Yes—please describe

When did these problems start?

Have these problems ended?

☐ No ☐ Yes—when?

VIII. Below is a list of items that describe children. For each item that describes your child **now or within the past 6 months**, please circle the 2 if the item is **very true** or **often true** of your child. Circle the 1 if the item is **somewhat** or **sometimes true** of your child. If the item is **not true** of your child, circle the 0. Please answer all items as well as you can, even if some do not seem to apply to your child.

0 = Not True (as far as you know) **1 = Somewhat or Sometimes True** **2 = Very True or Often True**

0 1 2 1. Acts too young for his/her age
0 1 2 2. Allergy (describe): _____
_____
0 1 2 3. Argues a lot
0 1 2 4. Asthma
0 1 2 5. Behaves like opposite sex
0 1 2 6. Bowel movements outside toilet
0 1 2 7. Bragging, boasting
0 1 2 8. Can't concentrate, can't pay attention for long
0 1 2 9. Can't get his/her mind off certain thoughts; obsessions (describe): _____
_____
0 1 2 10. Can't sit still, restless, or hyperactive
0 1 2 11. Clings to adults or too dependent
0 1 2 12. Complains of loneliness
0 1 2 13. Confused or seems to be in a fog
0 1 2 14. Cries a lot
0 1 2 15. Cruel to animals
0 1 2 16. Cruelty, bullying, or meanness to others
0 1 2 17. Day-dreams or gets lost in his/her thoughts
0 1 2 18. Deliberately harms self or attempts suicide
0 1 2 19. Demands a lot of attention
0 1 2 20. Destroys his/her own things
0 1 2 21. Destroys things belonging to his/her family or other children
0 1 2 22. Disobedient at home
0 1 2 23. Disobedient at school
0 1 2 24. Doesn't eat well
0 1 2 25. Doesn't get along with other children
0 1 2 26. Doesn't seem to feel guilty after misbehaving
0 1 2 27. Easily jealous
0 1 2 28. Eats or drinks things that are not food (describe): _____
_____
0 1 2 29. Fears certain animals, situations, or places, other than school (describe): _____
_____
0 1 2 30. Fears going to school
0 1 2 31. Fears he/she might think or do something bad
0 1 2 32. Feels he/she has to be perfect
0 1 2 33. Feels or complains that no one loves him/her
0 1 2 34. Feels others are out to get him/her
0 1 2 35. Feels worthless or inferior
0 1 2 36. Gets hurt a lot, accident-prone
0 1 2 37. Gets in many fights
0 1 2 38. Gets teased a lot
0 1 2 39. Hangs around with children who get in trouble
0 1 2 40. Hears things that aren't there (describe):
_____
_____
0 1 2 41. Impulsive or acts without thinking
0 1 2 42. Likes to be alone
0 1 2 43. Lying or cheating
0 1 2 44. Bites fingernails
0 1 2 45. Nervous, highstrung, or tense
0 1 2 46. Nervous movements or twitching (describe):
_____
_____
0 1 2 47. Nightmares
0 1 2 48. Not liked by other children
0 1 2 49. Constipated, doesn't move bowels
0 1 2 50. Too fearful or anxious
0 1 2 51. Feels dizzy
0 1 2 52. Feels too guilty
0 1 2 53. Overeating
0 1 2 54. Overtired
0 1 2 55. Overweight
56. Physical problems without known medical cause:
0 1 2 a. Aches or pains
0 1 2 b. Headaches
0 1 2 c. Nausea, feels sick
0 1 2 d. Problems with eyes (describe):
_____
0 1 2 e. Rashes or other skin problems
0 1 2 f. Stomachaches or cramps
0 1 2 g. Vomiting, throwing up
0 1 2 h. Other (describe): _____
_____

Please see other side

0 = Not True (as far as you know) 1 = Somewhat or Sometimes True 2 = Very True or Often True

0 1 2 57. Physically attacks people
0 1 2 58. Picks nose, skin, or other parts of body (describe): _____

80

0 1 2 59. Plays with own sex parts in public
0 1 2 60. Plays with own sex parts too much

16

0 1 2 61. Poor school work
0 1 2 62. Poorly coordinated or clumsy

0 1 2 63. Prefers playing with older children
0 1 2 64. Prefers playing with younger children

20

0 1 2 65. Refuses to talk
0 1 2 66. Repeats certain acts over and over: compulsions (describe): _____

0 1 2 67. Runs away from home
0 1 2 68. Screams a lot

25

0 1 2 69. Secretive, keeps things to self
0 1 2 70. Sees things that aren't there (describe):

0 1 2 71. Self-conscious or easily embarrassed
0 1 2 72. Sets fires

0 1 2 73. Sexual problems (describe):

30

0 1 2 74. Showing off or clowning

0 1 2 75. Shy or timid
0 1 2 76. Sleeps less than most children

0 1 2 77. Sleeps more than most children during day and/or night (describe): _____

0 1 2 78. Smears or plays with bowel movements

35

0 1 2 79. Speech problem (describe): _____

0 1 2 80. Stares blankly

0 1 2 81. Steals at home
0 1 2 82. Steals outside the home

0 1 2 83. Stores up things he/she doesn't need (describe):

40

0 1 2 84. Strange behavior (describe): _____

0 1 2 85. Strange ideas (describe):

0 1 2 86. Stubborn, sullen, or irritable

0 1 2 87. Sudden changes in mood or feelings
0 1 2 88. Sulks a lot

45

0 1 2 89. Suspicious
0 1 2 90. Swearing or obscene language

0 1 2 91. Talks about killing self
0 1 2 92. Talks or walks in sleep (describe):

0 1 2 93. Talks too much
0 1 2 94. Teases a lot

50

0 1 2 95. Temper tantrums or hot temper
0 1 2 96. Thinks about sex too much

0 1 2 97. Threatens people
0 1 2 98. Thumb-sucking

55

0 1 2 99. Too concerned with neatness or cleanliness
0 1 2 100. Trouble sleeping (describe):

0 1 2 101. Truancy, skips school
0 1 2 102. Underactive, slow moving, or lacks energy

0 1 2 103. Unhappy, sad, or depressed
0 1 2 104. Unusually loud

60

0 1 2 105. Uses alcohol or drugs (describe):

0 1 2 106. Vandalism

0 1 2 107. Wets self during the day
0 1 2 108. Wets the bed

65

0 1 2 109. Whining
0 1 2 110. Wishes to be of opposite sex

0 1 2 111. Withdrawn, doesn't get involved with others
0 1 2 112. Worrying

113. Please write in any problems your child has that were not listed above:

70

0 1 2
0 1 2
0 1 2

PLEASE BE SURE YOU HAVE ANSWERED ALL ITEMS.

UNDERLINE ANY YOU ARE CONCERNED ABOUT.

Table 1. Means and Standard Deviations of Physiological Measures for Ten Conduct Disordered Children Across Conditions

	BAS	INST1	TK1	RST	INST2	TK2	RCV
HR*							
Mean	48.10	48.50	49.47	48.40	48.20	49.07	49.00
SD	5.82	5.36	6.27	6.67	6.60	6.44	7.24
HRV*							
Mean	19.50	17.20	14.60	23.30	17.30	17.20	16.70
SD	14.68	10.59	8.67	20.02	12.21	14.21	13.96
EMG*							
Mean	14.44	16.06	7.55	12.85	15.71	7.02	18.10
SD	5.41	4.75	3.06	6.63	8.03	2.77	12.29

* HR is measured in beats per 30 seconds
* HRV is measured in greatest change in beats per second
* EMG is measured in spikes per minute above the mean motion
Each measure was calculated as noted in the results section of this paper

HR=heart rate
HRV=heart rate variability
EMG= forehead electromyography
BAS=baseline
INST1=instruction I
TK1=task 1
RST=rest
INST2=instruction 2
TK2=task 2
RCV=recovery

Table 2. Means and Standard Deviations for Systolic and Diastolic Blood Pressure in Ten Conduct Disordered Children Across Conditions

	BAS	TK1	RST	TK2	RCV
SBP					
Mean	105.90*	114.77	114.77	114.20	115.07
SD	10.27	7.77	8.46	9.04	7.25
DBP					
Mean	60.70	66.60	59.77*	67.17	66.23
SD	12.46	14.39	13.13	10.30	10.63

* SBP at BAS lower than RST $p < .0019$ by t-test
SBP at BAS lower than RCV $p < .0014$ by t-test
DBP at RST lower than RCV $p < .0487$ ty t-test

SBP=systolic blood pressure
DBP=diastolic blood pressure
BAS=baseline
TK1=task 1
RST=rest
TK2=task 2
RCV=recovery

Table 3 Comparison of the Two Groups on Measures of Impulsivity by t Test

	CD GROUP (N = 32)					CONTROL GROUP (N = 44)	
	Mean	SD	t	p	df	Mean	SD
AD							
ADI	8.84	5.39	1.71	.04*	74	10.71	4.07
ADE	7.48	3.73	.04	.97		7.51	2.82
ADS	3.36	2.91	-.27	.78		3.18	2.68
MFFT							
Latency	12.58	6.58	-.18	.85	74	12.32	5.90
Error	1.08	.66	-.29	.77		1.03	.66

*p < .05 by one-tailed t test

AD=arrow dot task MFFT=matching familiar figures tests
ADI=arrow dot impulsive score
ADE=arrow dot ego score
ADS=arrow dot superego score

Table 4 Correlation Matrix for Impulsivity Measures for Both Groups

Variables	Implat	Imperr	ADI	ADE	ADS
Implat					
control	___	-.66**	-.02	.18	-.02
CD group		-.64**	-.15	.06	-.11
Imperr					
control		___	-.12	-.05	.02
CD group			-.08	-.22	.26
ADI					
control			___	-.38*	-.44*
CD group				-.08	-.32
ADE					
control				___	.17
CD group					.29
ADS					
control					___
CD group					

* $p < .01$
** $p < .001$

Implat = Latency score by the Matching Familiar Figures Test
Imperr = Error score by the Matching Familiar Figures Test
ADI = Impulsive score by Arrow Dot Test
ADE = Ego score by Arrow Dot Test
ADS = Superego score by Arrow Dot Test

Table 5 Means and Standard Deviations of Physiological Measures for Both Groups Across Conditions

	Baseline	Video Game	Rest	Arrow-Dot Task	Recovery
GROUP WITH CONDUCT DISORDER					
HRV	21.13	19.34	19.19	22.88	25.53
SD	9.87	13.33	10.02	9.93	14.19
HR	73.66	79.09	76.31	78.28	77.34
SD	11.04	12.34	11.94	11.45	11.35
EMG	8.09	5.76	8.04	7.50	8.00
SD	7.60	6.54	8.30	7.65	8.18
EDA	8.41	7.25	3.03	4.09	4.38
SD	7.68	7.95	4.69	5.30	5.30
SBP	101.03	110.34	102.97	107.03	103.00
SD	10.54	12.17	10.07	10.94	10.65
DBP	63.06	63.94	62.91	64.22	63.75
SD	9.10	12.72	10.17	10.55	10.05
GROUP WITHOUT CONDUCT DISORDER					
HRV	21.89	23.52	23.27	23.83	21.89
SD	11.45	14.29	13.64	11.97	14.43
HR	76.36	79.07	79.16	79.34	79.00
SD	10.51	9.28	9.52	10.14	9.34
EMG	6.03	4.11	4.73	4.94	4.86
SD	6.51	5.25	4.56	4.28	4.88
EDA	14.89	8.93	5.11	6.11	6.98
SD	13.38	9.60	5.78	5.44	7.90
SBP	101.30	111.36	105.89	107.18	105.16
SD	11.39	9.95	9.83	12.06	10.03
DBP	61.80	65.73	61.36	60.54	62.66
SD	8.75	11.52	8.86	10.06	9.78

HRV=heart rate variability
HR=heart rate
EMG=forehead electromyography
EDA=electrodermal activity
SBP=systolic blood pressure
DBP=diastolic blood pressure

Table 6 Repeated Measures Analysis of Variance (ANOVA) for the Physiological Variables

SOURCE	df	SS	MS	F	p
HRV					
Between	75	36012.64			
Grps	1	148.18	148.18	.31	.582
Subj w Grps	74	35864.46	484.65		
Within	304	23673.18			
HRV	4	295.59	73.90	.97	.430
HRVxGrp	4	757.90	189.47	2.48	.044
Error	296	22619.72	76.42		
HR					
Between	75	39538.17			
Grps	1	251.85	251.85	.47	.493
Subj w Grps	74	39286.32	530.90		
Within	304	3048.39			
HR	4	737.78	184.44	24.76	.000
HRxGrp	4	105.71	26.43	3.55	.008
Error	296	2204.92	7.45		
EMG					
Between	75	10437.17			
Grps	1	601.26	601.26	4.52	.037
Subj w Grps	74	9835.90	132.92		
Within	304	5213.17			
EMG	4	173.52	43.38	2.57	.038
EMGxGrp	4	36.30	9.08	.54	.711
Error	296	5003.35	16.90		
EDA					
Between	75	13695.95			
Grps	1	818.91	818.91	4.71	.033
Subj w Grps	74	12877.04	174.01		
Within	304	13711.20			
EDA	4	3031.44	757.86	21.60	.000
EDAxGrp	4	292.83	73.21	2.09	.082
Error	296	10386.94	35.09		
SBP					
Between	75	28619.88			
Grps	1	157.10	157.10	.41	.524
Subj w Grps	74	28462.78	384.63		
Within	304	18656.80			
SBP	4	4025.30	1006.33	20.51	.000
SBPxGrp	4	107.96	26.99	.55	.701
Error	296	14523.54	49.07		

TABLE 6 (continued)

SOURCE	df	SS	MS	F	p
DBP					
Between	75	24296.99			
Grps	1	123.96	123.96	.38	.540
Subj w Grps	74	24173.03	326.66		
Within	304	14783.61			
DBP	4	464.58	116.15	2.45	.046
DBPxGrp	4	281.24	70.31	1.48	.206
Error	296	14037.78	47.42		

Table 7 Repeated Measures Analysis of Covariance: Comparison of Groups on the Video Game and the Arrow-Dot Task as a Measure of Physiological Reactivity*

Source	df	MS	F	p
HRV				
Between	75			
Covariate	1	6011.61	40.36	.000
Grps	1	165.60	1.12	.295
Subj w Grps	73	148.95		
Within	76			
HRV	1	104.45	1.15	.286
HRVxSwGrp	1	96.99	1.07	.304
Error	74	90.63		
HR				
Between	75			
Covariate	1	14605.31	781.17	.000
Grps	1	145.80	7.80	.007
Subj w Grps	73	18.70		
Within	76			
HR	1	1.29	.12	.731
HRxSwGrp	1	10.91	1.01	.319
Error	74	10.84		
EMG				
Between	75			
Covariate	1	1316.61	40.59	.000
Grps	1	57.82	1.78	.186
Subj w Grps	73	32.44		
Within	76			
EMG	1	55.80	2.70	.104
EMGxSwGrp	1	7.64	.37	.545
Error	74	20.63		
EDA				
Between	75			
Covariate	1	1334.21	21.72	.000
Grps	1	1.64	.03	.870
Subj w Grps	73	61.43		
Within	76			
EDA	1	333.06	10.42	.002
EDAxSwGrp	1	1.06	.03	.856
Error	74	31.95		

TABLE 7 (continued)

Source	df	MS	F	p
SBP				
Between	75			
Covariate	1	7674.54	91.33	.000
Grps	1	6.32	.08	.785
Subj w Grps	73	84.03		
Within	76			
SBP	1	553.29	8.16	.006
SBPxSwGrps	1	7.00	.10	.749
Error	74	67.85		
DBP				
Between	75			
Covariate	1	4471.06	34.80	.000
Grps	1	.96	.01	.931
Subj w Grps	73	128.47		
Within	76			
DBP	1	315.53	4.96	.029
DBPxSwGrps	1	276.46	4.35	.040
Error	74	63.62		

*Baseline values for the individual measures are the covariate.

Table 8 Repeated Measures Analysis of Covariance: Comparison of Groups on RCV1 and RCV2 as a Measure of Physiological Recovery*

Source	df	MS	F	p
HRV				
Between	75			
Covariate	1	2585.04	16.97	.000
Grps	1	45.70	.30	.586
Subj w Grps	73	152.30		
Within	76			
RCV	1	1.68	.01	.915
RCVxSwGrps	1	187.11	1.29	.260
Error	74	145.50		
HR				
Between	75			
Covariate	1	100.14	5.52	.023
Grps	1	111.20	6.13	.016
Subj w Grps	73	18.14		
Within	76			
RCV	1	10.53	.92	.341
RCVxSwGrp	1	47.97	4.18	.044
Error	74	11.47		
EMG				
Between	75			
Covariate	1	57.23	2.79	.099
Grps	1	62.97	3.08	.084
Subj w Grps	73	32.44		
Within	76			
RCV	1	50.48	1.89	.174
RCVxSwGrp	1	10.92	.41	.525
Error	74	26.74		
EDA				
Between	75			
Covariate	1	1186.57	49.12	.000
Grps	1	39.02	1.62	.208
Subj w Grps	73	24.15		
Within	76			
RCV	1	805.92	15.59	.000
RCVxSwGrp	1	.31	.01	.939
Error	74	51.70		

TABLE 8 (continued)

Source	df	MS	F	p
SBP				
Between	75			
Covariate	1	966.23	13.17	.000
Grps	1	178.27	2.43	.123
Subj w Grps	73	73.39		
Within	76			
RCV	1	441.32	3.92	.051
RCVxSwGrps	1	.11	.00	.975
Error	74	112.43		
DBP				
Between	75			
Covariate	1	2179.94	22.86	.000
Grps	1	1.40	.02	.904
Subj w Grps	73	95.36		
Within	76			
RCV	1	604.01	7.72	.007
RCVxSwGrps	1	324.08	4.14	.045
Error	74	78.20		

*Task I values for the individual measures are the covariate.

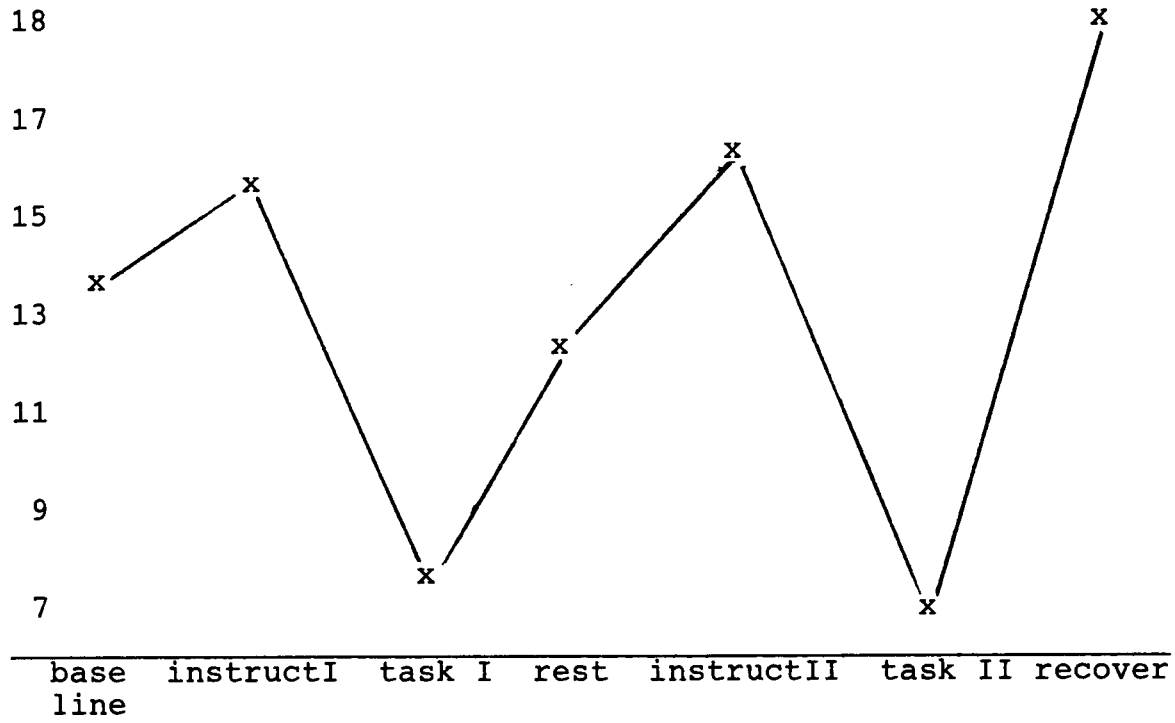


Figure 1. Mean forehead EMG in spikes/minute for baseline, instruction I, task I, rest, instruction II, and recovery.

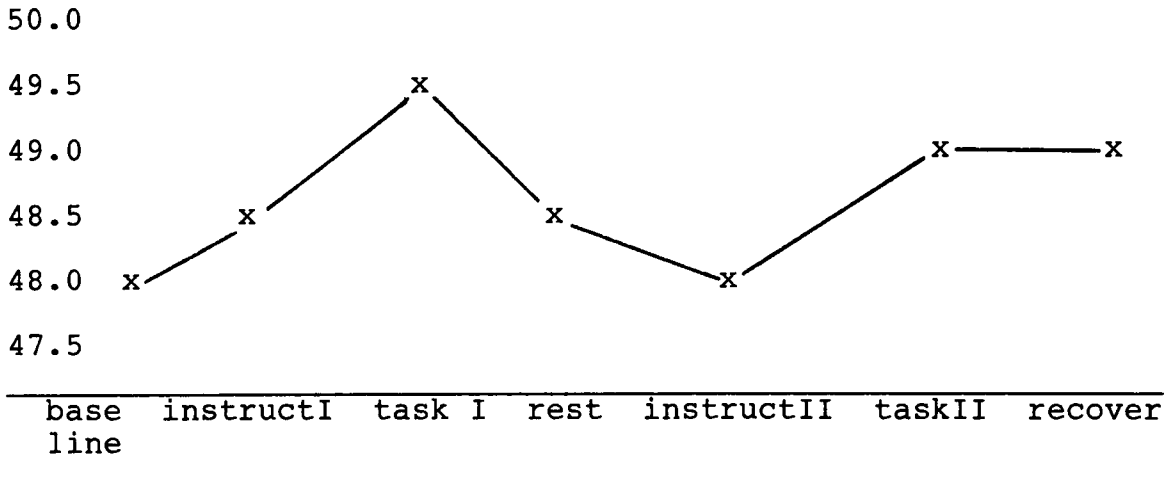


Figure 2. Mean heart rate in beats/30 seconds for baseline, instruction I, task I, rest, instruction II, task II, and recovery.

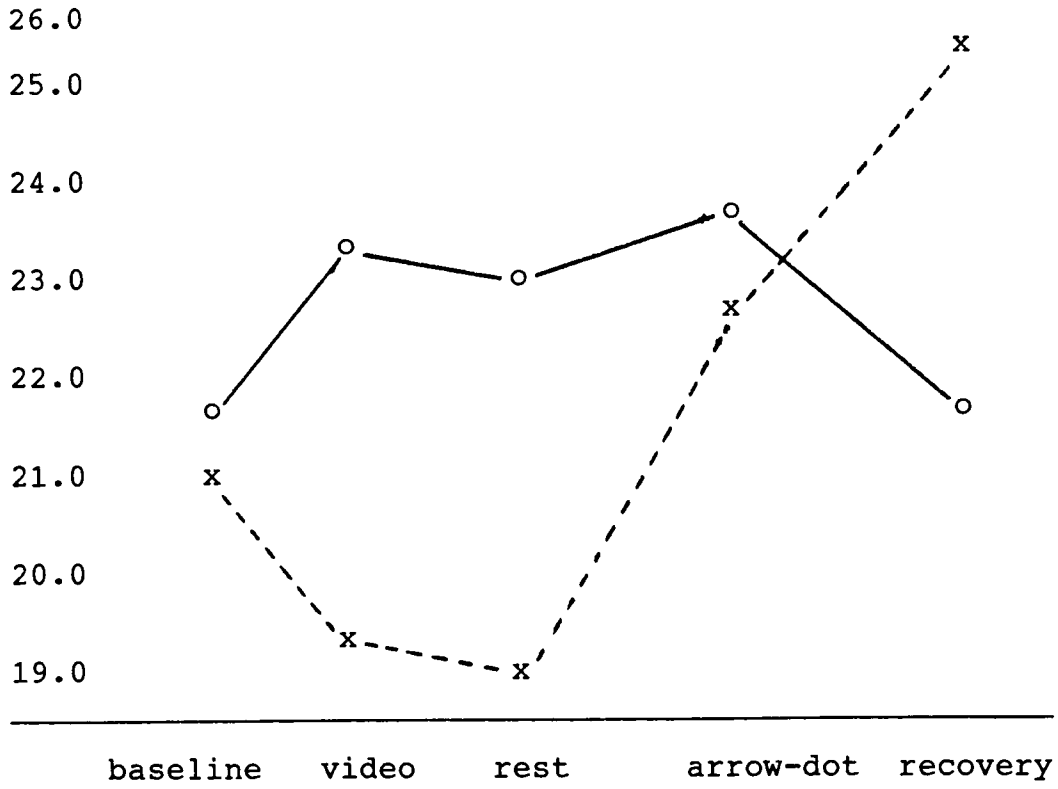


Figure 3. Mean heart rate variability in beats/minute for baseline, video game, rest, arrow-dot task, and recovery for both groups.

CD group = x
Control group = o

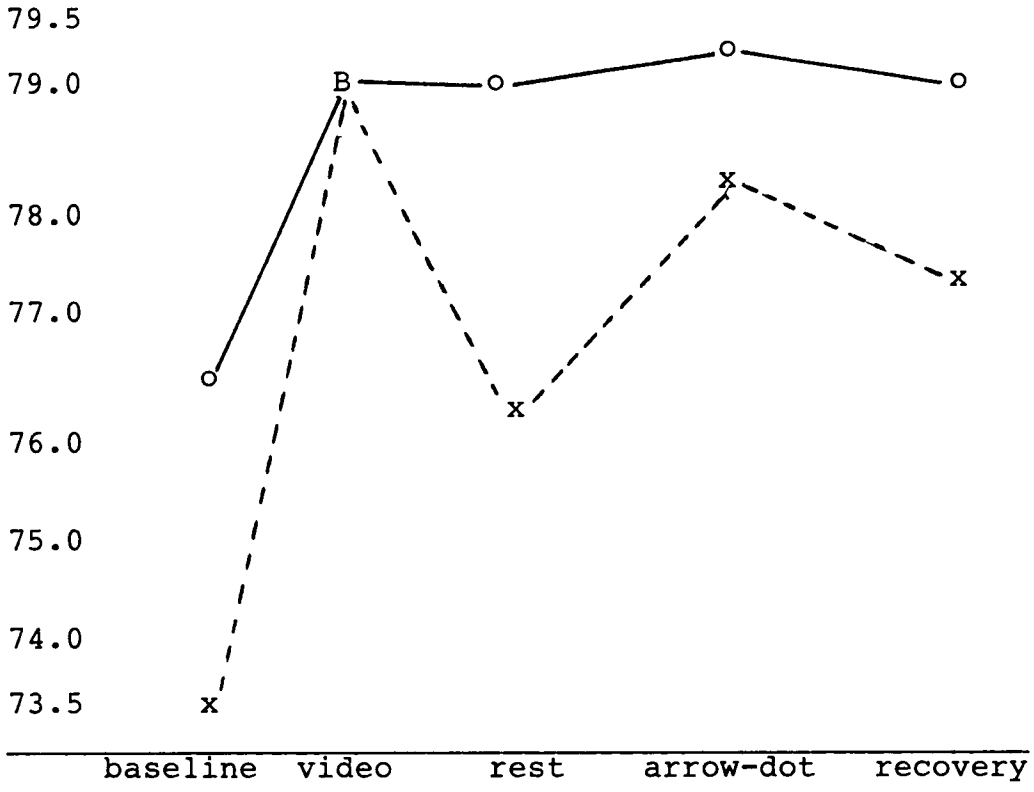


Figure 4. Mean heart rate in beats/minute for baseline, video game, rest, arrow-dot task, and recovery for both groups.

CD group = x
Control group = o
Both groups = B

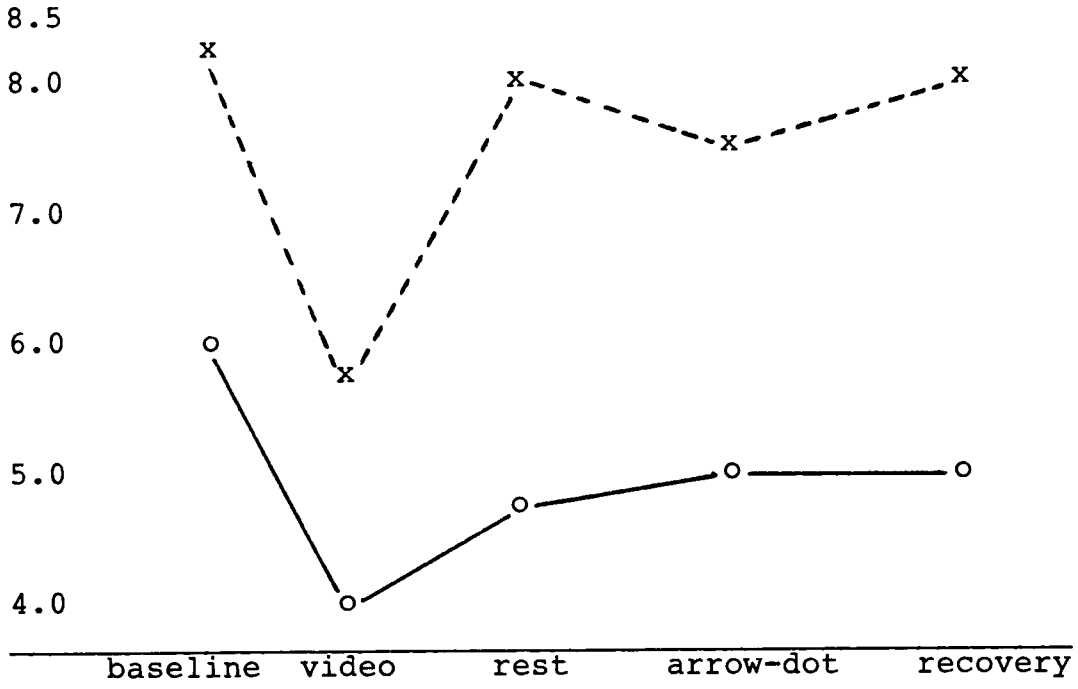


Figure 5. Mean forehead EMG in spikes/minute for baseline, video game, rest, arrow-dot task, and recovery for both groups.

CD group = x
Control group = o

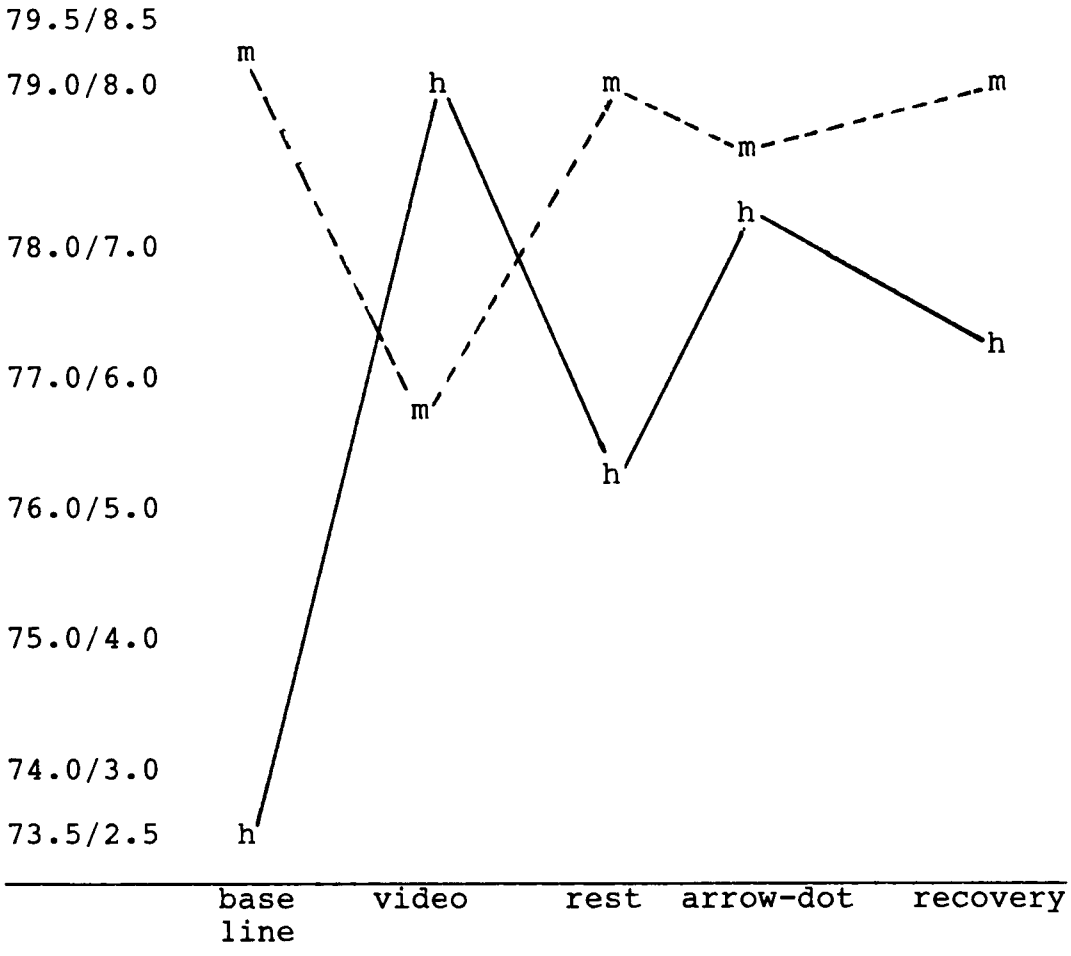


Figure 6. Mean heart rate in beats/minute and mean forehead EMG in spikes/minute for baseline, video game, rest, arrow-dot task, and recovery for the conduct disorder group.

Heart rate = h
Forehead EMG = m

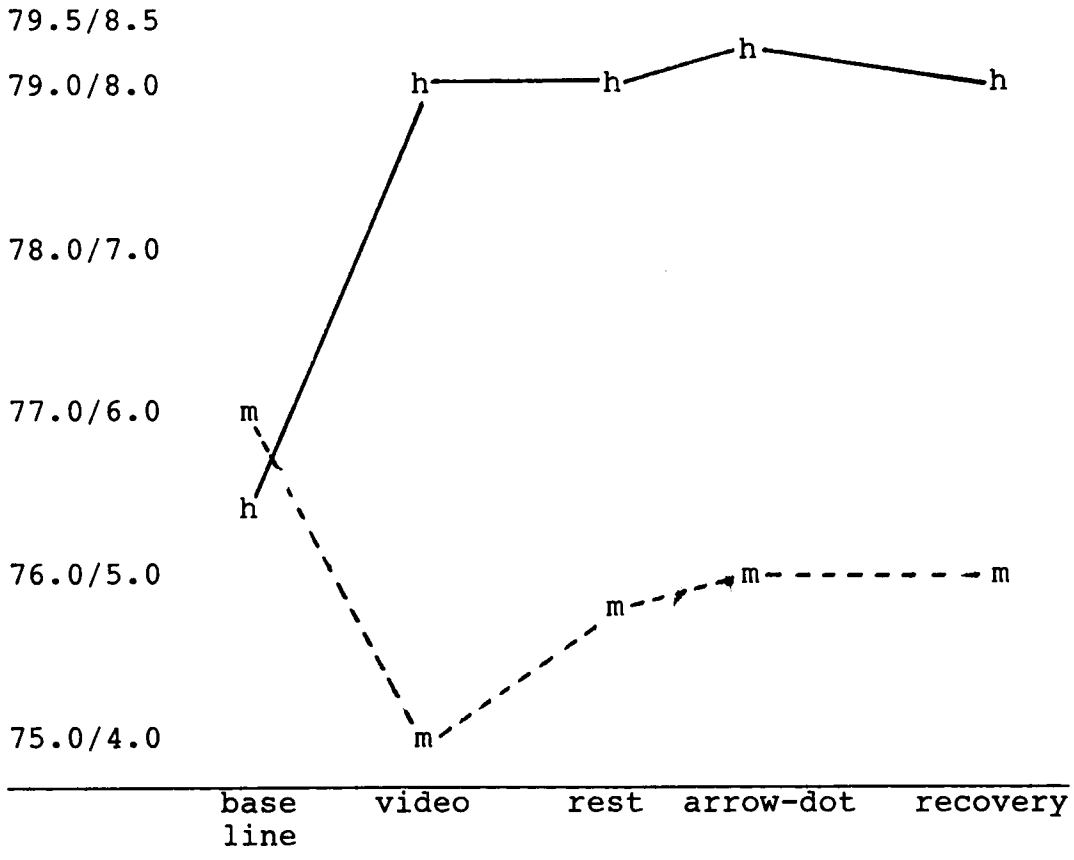


Figure 7. Mean heart rate in beats/minute and mean forehead EMG in spikes/minute for baseline, video game, rest, arrow-dot task, and recovery for the control group.

Heart rate = h
Forehead EMG = m

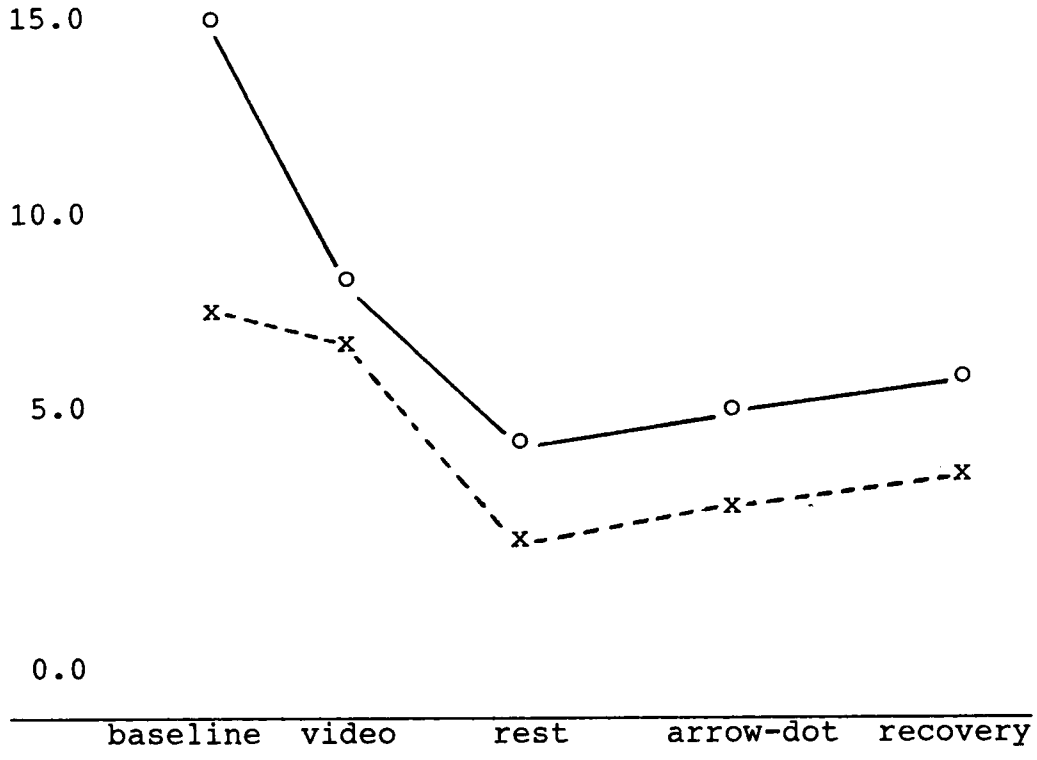


Figure 8. Mean electrodermal activity in spontaneous fluctuations/minute for baseline, video game, rest, arrow-dot task, and recovery for both groups.

CD group = x
Control group = o

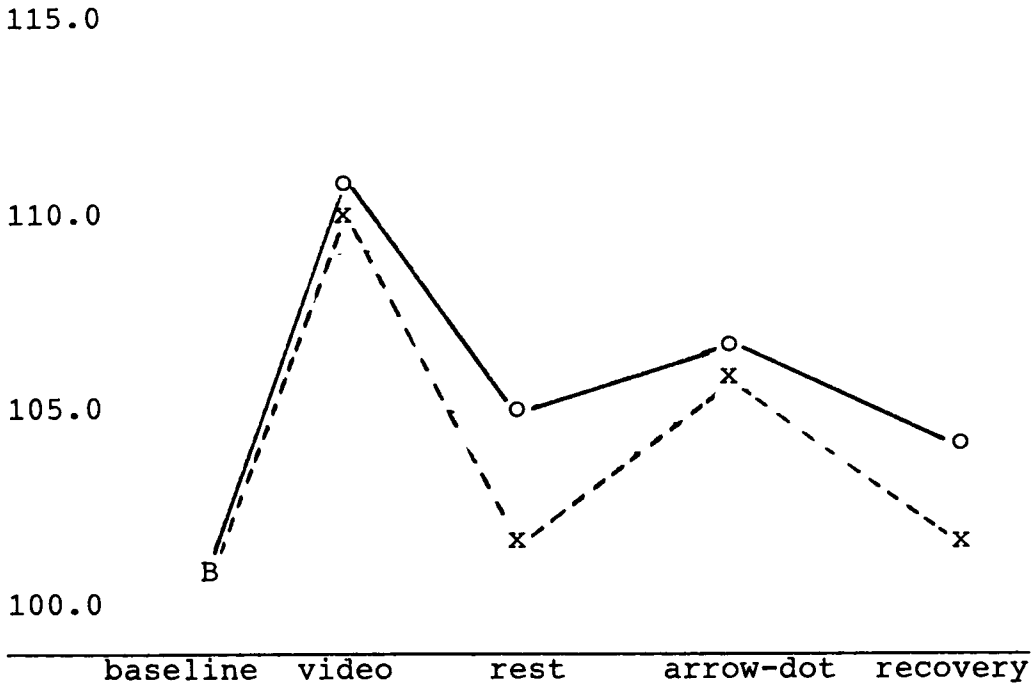


Figure 9. Mean systolic blood pressure in mm Hg. for baseline, video game, rest, arrow-dot task, and recovery for both groups.

CD group = x
Control group = o
Both groups = B

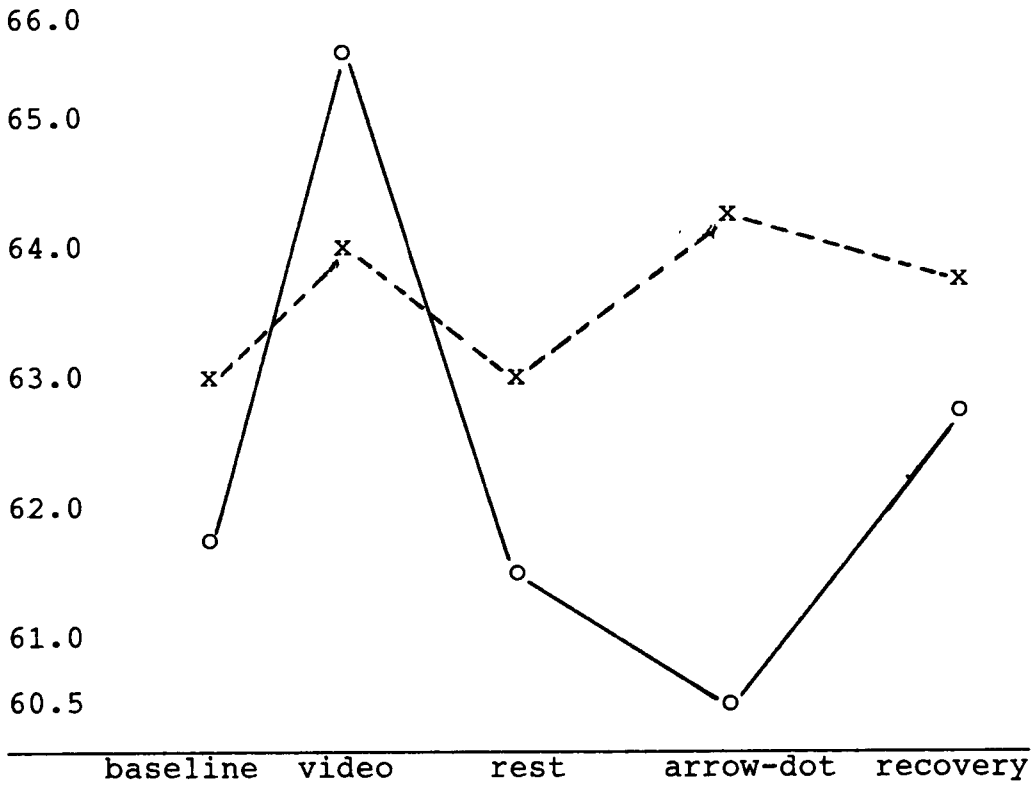


Figure 10. Mean diastolic blood pressure in mm Hg. for baseline, video game, rest, arrow-dot task, and recovery for both groups.

CD group = x
Control group = o

VITA

Theresa Lyla Tucker was born in Barre City, Vermont on June 7, 1953. She attended Chelsea Elementary and High School, Chelsea, Vermont where she graduated in June, 1971. The following August she entered the University of Vermont and in May, 1973 received an Associate Degree in Nursing. In the fall of 1979 she entered Hawthorne College where she majored in Psychology and received a Bachelor of Arts Degree in the winter of 1982. She began the Clinical Psychology program at The University of Tennessee, Knoxville in September, 1985 and received a Doctor of Philosophy Degree in August, 1991.