CHARACTERISTICS OF CHILDREN WHO SURVIVED INFANTILE APNEA

By

DANA DEARDEUFF

Bachelor of Science
University of Oklahoma
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Master of Science
Oklahoma State University
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Thesis:

Joan Holloway

Thesis Adviser

Brent Snow

James M. Price

J. B. Thomas

Norman N. Durham

Dean of the Graduate College

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CHAPTER I

CHARACTERISTICS OF CHILDREN WHO SURVIVED INFANTILE APNEA

Apnea

Apnea is defined as pauses in the breathing process. The flow of gases in and out of the body is temporarily interrupted. When the interruption occurs for 10 seconds or less, it is generally termed "periodic" apnea (Henderson-Smart & Cohen, 1986). These brief interruptions have no apparent clinical significance as they are observed in all healthy infants. When the interruptions exceed 20 seconds, the American Academy of Pediatrics defines these episodes as pathological apnea. This same definition is applied to apnea of a duration shorter than 20 seconds if it is accompanied by low heart rate or bradychardia. Pathological apnea is of clinical relevance due to the resulting anoxia and cardiovascular disturbances, which can affect brain functioning.

Pathological apnea occurring during the sleep cycle has been indicated as a causal factor in some cases of Sudden Infant Death Syndrome (SIDS). SIDS is the leading cause of death for children between 1 and 12 months of age, with the risk estimated at one to three deaths per 1,000 live births. This syndrome peaks at 2 to 4 months of age and is most commonly found in premature, low birthweight, male, black, low socio-economic status (SES), and blood

type B infants. A great deal of evidence shows that prior to their death, SIDS infants had experienced episodes of apnea during their sleep, and may have needed resuscitation (Merritt, Bauer & Hasselmeyer, 1975).

Three forms of apnea are described in the literature: central, obstructive and mixed. Central apnea occurs when the cessation of breathing is accompanied by no movement of the respiratory muscles in the abdomen and chest. Obstructive or upper airway apnea is characterized by a termination of breathing with the presence of movement in the chest or abdomen. This form of apnea generally involves a greater loss of oxygen from the blood. Mixed apnea is characterized by a period of central apnea followed by obstructive apnea. Apneic infants generally experience more than one of these types of apnea.

A common problem with apneic infants is bradycardia, usually defined as a heart rate of less than 100 beats per minute with a duration of 2 seconds or more (Darwish & McMillan, 1984). When bradycardia occurs within ten seconds of onset of an apneic episode, it is termed immediate or reflexive bradycardia. This is presumed to be a reflex due to the anoxia associated with apnea. Other differences in cardiac and autonomic functioning have been demonstrated including greater heart rate variability with a habituation paradigm in a group of apneic infants compared to controls (Holloway, Deardeuff, Gerrity, Bendell, & McCaffree, 1987).

Mechanisms of Apnea

The underlying mechanisms of apnea are not fully understood to date. Many researchers (Rigatto & Brady, 1972; Henderson-Smart & Cohen, 1986; Martin, Miller & Carlo, 1986; Mathew, 1986) suggest that the inability of the infant to monitor and breathe adequately is due to immaturity of the central nervous system (CNS). There appears to be a large scale deficit in autonomic nervous system modulation.

Regardless of the causal mechanisms, it is clear that these infants experience varying degrees of oxygen deprivation during apneic episodes. This type of deprivation has previously been termed hypoxia, asphyxia and anoxia. For the purposes of this paper, the oxygen deprivation experienced by apneic infants will be called anoxia.

CNS Dysfunction of Anoxia

The CNS may be significantly damaged during anoxia due to the interference with efficient cerebral circulation. However, newborns can survive degrees of anoxia that would be fatal in later life (Rosenfield & Bradley, 1948). Research suggests that the damage is highly variable between individuals, which can range from massive cell death to no evidence of damage at all.

There are many physical consequences resulting from anoxia aside from the decrease in the oxygen supply (Spreen, Tupper, Risser, Tuokko & Edgell, 1984). One effect is that the generation of energy switches from aerobic to anaerobic.

This switch leads to a depletion of the energy reserves in the brain. Also, toxic waste products such as carbon dioxide and lactic acid begin to accumulate in the brain contributing to the neurological damage. The brain demands a great deal of oxygen constantly and has a great deal of blood flowing thought it at any given time. Consequently, the brain is most vulnerable of all vital organs to anoxia and the stagnation of circulation. A further complication is that in general gross damage is irreversible since cells do not regenerate in the brain.

The duration and degree of reduction of oxygen levels, as well as age of the patient, are important factors when considering the possible damage from anoxia. For cerebral injury to occur, the oxygen deprivation must be of sufficient degree and duration to cause permanent cell damage (Darke, 1944). Apneic infants experience oxygen deprivation repeatedly during a crucial developmental period.

Intelligence

The resulting effects of anoxia on intelligence have been studied extensively with conflicting results. Early research determined a statistically significant decrement in IQ in children who had suffered perinatal complications including asphyxia (Schacter & Apgar, 1959). In 1973, Gottfried conducted a critical review of the literature on perinatal anoxia. He concluded that the cognitive deficits found were more prevalent during infancy and preschool than in older children. The differences appeared to

dissipate over time. He also concluded that there were no specific deficits that could be conclusively outlined, including mental retardation. He stated that the probability of a child having mental retardation was increased by anoxia but not determined by it.

A longitudinal study conducted by Broman (1979) reports only a small degree of variability in later cognitive functioning of children who experienced perinatal anoxia. More recent research concludes that there are early developmental delays but no serious longterm effects on mental development (Nikaido, 1983; Tudehope, Rogers, Burns, Mohay & O'Callaghan, 1986). Thus, anoxia appears to be a weak predictor of late intellectual performance with no long term correlation with IQ.

Neuropsychology

The effects of anoxia are not as short lived in other realms of study, however. When investigating neurological development, significant effects of early anoxia are evident. Graham (1962) concluded that anoxic subjects exhibit positive and suggestive neurological findings significantly more often than control subjects. Other investigators (Bacola, Behrle & de Schweinitz, 1966; Stewart & Reynolds, 1974) have implicated anoxia as a potential cause of neurological differences in surviving infants. Similarly, research presented at the 1988 Sixth Annual Conference on Apnea of Infancy by Coleman, Stading, Tuma, Boros & Mammel (1988) found a high incidence of neurodevelopmental abnormalities after longterm follow-up.

Similar research conducted with infants who experienced respiratory distress syndrome (RDS) report the same results. Fisch, Gravem & Engel (1968) supported the association of increased incidence of neurological abnormalities with surviving infants of RDS. The probability of neurological impairment resulting from anoxia is significant, and subjects frequently display some type of abnormalities.

Behavioral and Temperament Characteristics

Moreover, apneic subjects display behavioral and temperament differences from control subjects. Graham (1962) reported that anoxic subjects at 3 years of age were significantly more distractible than control subjects. Likewise, Field, et al. (1978) concluded that RDS infants were inattentive and rated as having difficult temperaments. Lasky, et al. (1983) studied infants who required ventilation at birth and found they were rated as more active with shorter attention spans than their controls during infancy.

Rosenfield and Bradley (1948) investigated behavioral sequelae of asphyxia occurring during different ages (0-5) of childhood. The subject ages at testing ranged from 3 to 13 years, and all subjects were obtained from a children's psychiatric hospital. They concluded that there were six cardinal behavioral characteristics of the inpatient children who experienced asphyxia. These characteristics were: unpredictable variability in mood, hypermotility, impulsiveness, short attention span, fluctuant

ability to recall material previously learned and difficulty in arithmetic.

Research conducted on apneic infants (Bendell, Culbertson, Shelton & Carter, 1986; Bendell, McCaffree, Garst, LaVore, Gerrity, & Holloway, submitted) found similar results to the Rosenfield study. These infants were perceived as more active and were viewed as less "acceptable" by their mothers. The researchers concluded that these infants were at risk for negative evaluation later in life.

Hyperactivity

The characteristics used to describe children who experienced anoxia are similar to some descriptors for the hyperactive child. The American Psychiatric Association's Diagnostic and Statistical Manual-III-Revised (1987) labels the disorder Attention Deficit Hyperactivity Disorder (ADHD) and the criteria used for diagnosis are listed in Table 1.

Insert Table 1 about here

They further describe the hyperactive child as inappropriately innattentive, impulsive and hyperactive. This can be evidenced by a child whose behavior is restless and inattentive to a qualitatively and quantitatively different degree than a matched control (O'Leary, 1980).

Hyperactivity is a relatively common disorder occurring in as many as 3% of children. The disorder is much more prevalent in

males, with a 3 or 4 to 1 ratio. The disorder generally onsets before the age of four but is most frequently recognized when the child begins school. Hyperactivity does not appear to be related to race, birth order, number of siblings, parental age, educational level, income, or marital status (Whalen, 1983).

The label of ADHD includes a diverse group of children and some investigators believe there may be subgroups of the disorder (Achenbach, 1982; Whalen, 1983). Many different hypotheses have been proposed to account for hyperactivity: brain damage, neurotransmitter abnormalities, abnormal arousal, food sensitivities or allergies, and developmental delays. Achenbach (1982) reports that there is a weak correlation between perinatal abnormalities and later hyperactivity, which might account for one subgroup of the disorder. All hypotheses find some support in the research, further indicating the diversity of this population. The characteristics exhibited by these children may be caused by a number of factors, all encompassed under one diagnosis. In reality, there may be many possible underlying causes in the broad category of ADHD.

Research has revealed some test patterns for hyperactive children. They tend to have normal IQ's (Whalen, 1983) but do not necessarily equal their peers in ability. ADHD children tend to have some deficits in performance involving inattention and impulsivity. Neurological tests find some neurological dysfunction, but these findings are not universal to the ADHD population. Finally, many behavioral checklists have been constructed empirically to differentiate these children from others, indicating

relative ease in distinquishing a "hyperactive child" profile.

Rationale

The present study investigated characteristics of children who survived apnea of infancy. Apnea leads to anoxia, and anoxia has effects on intellectual, neuropsychological and temperamental characteristics of the individuals. These effects of anoxia and the resulting description of the subjects have been demonstrated to be similar to those children described as hyperactive. Therefore, apnea of infancy may be one of several possible precursors to childhood hyperactivity. The duration and severity of the apneic episodes could determine the degree of "hyperactive" behavior exhibited by the child and subsequent ADHD diagnosis.

Early intervention in the learning process of hyperactive children has been beneficial. Different teaching methods are frequently employed with these children to address the impulsive and inattentive behavior. These methods allow the child to learn in an individualized manner, which can reduce possible learning disabilities displayed by hyperactive children. Similarly, techniques such as self-talk can be employed by the child to minimize their hyperactive behavior.

This study investigating the characteristics of children who were apneic as infants, might determine that these children are at risk for hyperactivity. The study may also find that these children are, indeed, more likely to be diagnosed as hyperactive in their early childhood years. This description might aid the practitioner

in predicting some consequences of apnea (i.e. hyperactivity) and allow for appropriate early interventions to minimize the negative effects of such consequences.

In this study, two groups were compared: (1) a group of children who were apneic as infants; and (2) a control group of normal children. It was hypothesized that the apneic subjects would differ significantly from the controls in behavior ratings, IQ patterns and neuropsychological testing. These differences were predicted to parallel the patterns of a hyperactive child.

More specifically, it was predicted that the apneic group would be rated behaviorally as inattentive, overactive, distractible, and impulsive. These behavior ratings would place the subjects in the significance region on the hyperactive scale of the checklist. The IQ patterns for the apneil group would reflect those frequently found in hyperactive children: relatively lower scores on arithmetic, coding and digit span; more inter-subtest variability; and a low score on freedom from distractibility. The neuropsychological testing would reveal greater variability and differences in performance.

CHAPTER II

METHODS

Subjects

Nineteen subjects per group, apneic and control, were recruited from various sources in Oklahoma. Screening procedures were conducted initially to insure that subjects met some general criteria as well as those criteria for their designated group. All subjects participated on a voluntary basis. Parents were given an interpretation of the cognitive testing in exchange for their child's participation.

All subjects met the following criteria, which were met easily with a low exclusion rate:

1) between 6 and 8 year of age. Subjects were 6 years of age to insure that they were enrolled in school, and 8 years of age due to the upper limit of the apneic group from a previous study (Holloway, et al., 1987);

2) currently enrolled in school;

3) had not taken the tests being administered in the study within the past 6 months;

4) had no history of brain injury, seizures, or other CNS dysfunction;

5) had no major physical disabilities such as blindness, etc.

6) were not taking any prescription or over the counter medication on a regular basis, or within the last 2 weeks before participation. It should be noted that no children were excluded for taking Ritalin, a common treatment for hyperactivity.

The group of apneic subjects must have been on home monitors for apnea during infancy and were, therefore, clinically diagnosed as apneic. To be placed on a home monitor, the infant would have experienced at least one episode of xygen deprivation. (Home monitors are alarm systems used when an infant is diagnosed as apneic. These systems require three electrodes to be attached to the infant's body during sleep. If the infant's heart rate becomes abnormally low or breathing stops, the alarm will sound.) All apneic subjects had completed a sleep study as an infant to document the apnea. These subjects were obtained from Children's Hospital of Oklahoma in Oklahoma City, Oklahoma. The children in the apneic group had previously participated in an apnea research project during infancy.

Subjects in the control group met the general criteria and additionally had no history of apnea. Subjects recruited were primarily friends or siblings of other participants.

Materials

A consent form (see Appendix A) explaining confidentiality, willingness to participate and possible compensation for the proposed study was used. To gather personal information for later contact, to assess SES, and to aid in assessment of subject

suitability the subject identification questionnaire (see Appendix B) was used. In addition, a number of questions were asked about developmental milestones of the child, which are included in a screening questionnaire (see Appendix C). Finally, an additional questionnaire was used for the experimental group, to gather specific information about the apnea (see Appendix D).

Three tests were administered to each child in this study: Wechsler Intelligence Scale for Children-Revised (WISC-R, 1974), parts of the Kaufman Assessment Battery for Children (K-ABC, 1983a), and the Child Behavior Checklist-Parent Version (CBCL, 1983).

The WISC-R is a test designed to measure general intelligence in children ages 6-16. The twelve subtests were administered in a standard manner and a verbal (VIQ), performance (PIQ), and full scale IQ (FSIQ) were obtained.

The WISC-R was well standardized on 2,200 children with a representative sample from the population (Goldman, Stein & Guerry, 1983). Reliability tests of the three IQ scores have been reported from .89 to the mid .90's, with a standard error of measurement for the full scale IQ of 3 points. Subtest reliability coefficients range from .70 to .86 (Sattler, 1982). The WISC-R full scale IQ correlates .82 with the Stanford-Binet, yielding a high concurrent validity. This test is generally considered the standard IQ test when examining a child in the appropriate age range with an IQ above 45.

Three factors have emerged from a factor analysis of the standardization group (Kaufman, 1975) that identified more

meaningful psychological dimensions. The verbal comprehension factor (Ver Comp) appears to measure verbal knowledge and comprehension. Part of this factor is enhanced by formal schooling while the remainder is the child's ability to apply verbal skills to novel situations. A second factor, known as the perceptual organization factor (Per Org), is a nonverbal measure. Perceptual and organizational dimensions are reflected in this score, which include the ability to visually interpret and organize material. Freedom from distractibility (FD) is the final factor which measures the ability to attend to task and concentrate undistracted. Numerical ability may also be reflected in this factor (Sattler, 1982).

The K-ABC was designed to measure intelligence and achievement for children ages 2 1/2 to 12 1/2 years. The battery yields four standard scores with a mean of 100 and standard deviation of 15. These four global areas are: sequential processing, simultaneous processing, mental processing composite (sequential processing + simultaneous processing), and achievement. While the test consists of 16 subtests, only 8 subtests were utilized in this study: hand movements, number recall, word order, gestalt closure, triangles, matrix analogies, spatial memory, and photo series. These subtests combine to give the three global scores of sequential processing (Seq Proc), simultaneous processing (Sim Proc) and the mental processing composite (MPComp) for the 6-8 age range. The other subtests are either not appropriate for this age range or are utilized in the achievement scale. This scale was not important to

this study.

The K-ABC was developed from neuropsychological theory (Kaufman & Kaufman, 1983b) to aid in evaluation of brain-behavior relationships. The sequential versus simultaneous scales reflect cerebral specialization theory similar to the Luria-Nebraska battery. The K-ABC appears to detect deficits in cortical functioning (Kamphaus & Reynolds, 1987). While the research is limited to date, it has been supportive of using the K-ABC in a neuropsychological test battery. Studies comparing the K-ABC to the Luria-Nebraska conducted by Snyder, Leark, Golden, Grove and Allison in 1983 (cited in Kamphaus & Reynolds, 1987) have generally found high correlations between the two tests.

Standardization was conducted with a stratified sample of more than 2,000 children in 24 states (Kaufman & Kaufman, 1983b). Split-half reliability for the global scales ranges from .86 to .97. Test-retest reliability has ranged from .77 to .97 across the varied ages. Construct validity has been evidenced by evaluation in five main areas: developmental changes, internal consistency, factor analysis, convergent and discriminant validation, and correlations with other tests.

The CBCL was constructed by Achenbach and Edelbrock in 1983. This behavior rating scale is completed by the parents, requiring a fifth grade reading level, or can be administered verbally by the examiner. The parent or caretaker completes the questionnaire on a three-point scale with some open ended questions (e.g. three activities your child participates in). The CBCL takes

15-20 minutes to complete and is appropriate to rate the behavior of children ages 4-16.

The test was standardized on 500 subjects, normals and those from mental health settings. Overall, interscorer reliability has been estimated at .95, with .927 for the social competence items (Achenbach & Edelbrock, 1983). Interparent reliability has been reported as .978 for social competence items and .985 for the 118 behavior problems. Convergent validity has been reported from .45 to .85 for the individual factors. Discriminant validity is sufficient to discriminate clinical from non-clinical samples (Martin, Hooper & Snow, 1986).

There are two sets of factors rated by the CBCL. The broadband or primary order factors are internalizing and externalizing. The narrowband or second order factors on the Child Behavior Profile (CBP) that were utilized in this study include the following: depression, somatic complaints, hyperactivity, aggressive, delinquency, social competency (Soc Comp), and composite behavior problems (Beh Prob). The scored profile consists of percentiles and T scores by comparing the child to typical children of the same age and sex.

Procedure

Parents were contacted by telephone to determine willingness to participate. At that time risks and benefits of participation in this research were explained to the parents. It was also explained that all information is confidential and data is maintained under

number codes. If the parents were willing for their child to participate, the screening interview was conducted at that time. The screening interview consisted of the subject identification questionnaire and the screening questionnaire. The screening questionnaire was administered verbally by the research coordinator to insure the proper information was gathered. If the screening and subject identification materials met the criteria for the designated group, a 3-4 hour appointment for testing was scheduled.

Subjects were tested in a conference room at Children's Hospital of Oklahoma. There were no distractors, such as toys in the room, only furniture, pictures on the walls and the proper testing materials. The child and examiner were the only persons present in the room during testing. There were 4 examiners who were enrolled in the psychology graduate program at Oklahoma State University. These examiners had taken the required testing courses demonstrating competency in testing procedures.

Prior to the testing, the parents signed the consent form. Then, the child was escorted into the testing room. While the child was being tested, the parent completed the CBCL.

The tests were administered according to the standard administration procedures provided in the test manuals (Wechlser, 1974; Kaufman & Kaufman, 1983a) and the examiner was blind as to group membership. The tests were administered in varied order. After completion of the first test, a fifteen minute break was taken with all subjects. During this time, the subject was taken to their parent, allowed to use the restroom and offered a drink of water. Following this break, the final test was administered.

CHAPTER III

RESULTS

Summary of subject age, SES and sex are presented in Table 2. SES was assessed using the Hollingshead Four Factor Index of Social Status (1975). A two tailed t test revealed no significant

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Insert Table 2 about here

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difference between the two groups in age representation, $t(36) = -0.66$, $p > .05$. Similarly, when analyzing the SES data, a two tailed t tested revealed no significant difference, $t(36) = 1.99$, $p > .05$. As shown in Table 2, sex was equally represented in both groups. Minorities were also equally represented between groups, with 2 subjects in each group. Since these subject factors did not present a significant effect, they were not utilized in further analyses.

Data collected on testing materials was analyzed using multiple t tests. Due to the use of multiple comparisons, Dunn's multiple comparison procedure was utilized in determining the critical value. The means, standard deviations and t values are presented in Table 3. No significant differences were found on any of the measures listed.

Insert Table 3 about here

To determine if severity of apnea might be an important factor, the experimental group was divided into two groups. Utilizing the apnea information questionnaire, subjects were rated on severity of apnea by number of times resuscitated as follows: rarely (0-2 times) - 1; sometimes (3-10 times) - 2; frequently (weekly) - 3; and regularly (nightly) - 4. Severe apneics had a rating of 3 or 4 while control apneics rated 1 or 2. Data for the severe apneics (n = 5) were compared to the remaining control apneics (n=14) using Welch's t test. Again, critical value was determined using Dunn's

Insert Table 4 about here

multiple comparison procedure. The means, standard deviations and t values are in Table 4. No significant differences were found between these two subgroups.

The group of severe apneics (n=5) was then compared to the original control group (n=19), utilizing Welch's t test. Critical value was determined using Dunn's multiple comparison procedure.

Insert Table 5 about here

The means, standard deviations and t values are presented in Table 5. There were no significant differences between the control and

severe apneic groups.

Finally, to determine if there is a relationship between severity of apnea and scores on the tasks, the Pearson product-moment correlation method was used. Correlation coefficients were calculated on the 18 measures for the apnea group with their

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Insert Table 6 about here

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corresponding severity rating, these are presented in Table 6. Due to multiple comparisons, Dunn's method was once again used to determine critical value. No significant differences were found.

CHAPTER IV

DISCUSSION

The results of this investigation do not support the hypotheses presented. There were no significant differences between the apneic and control groups on IQ, behavioral or neuropsychological measures. Similarly, when the apneic group was divided into a group of severe and a group of less severe apneics there were no significant differences.

With respect to intelligence, these results support current research in this area. Tudehope et al. (1986) found no direct relationship between apnea and intellectual deficits. Other researchers (Gottfried, 1973; Nikaido, 1982) have also supported the absence of an effect, especially at later ages. It appears that while there may be differences during infancy and early childhood on measures of cognitive functioning (Schacter & Apgar, 1959; Gottfried, 1973), as the children age the differences are no longer evident as determined by the WISC-R.

The neuropsychological results are contradictory to other studies investigating the effects of anoxia. While most researchers have found suggestive implications of neuropsychological deficits subsequent to anoxia, the studies were not conducted at later ages. Fisch et al. (1968) investigated subjects during the first year of life, Coleman et al. (1988) followed subjects until 18 months and Graham et al. (1962) studied subjects only as newborns. The

differences found by these researchers at the early ages are not supported by the present research, studying older subjects. The current study suggests that the children mature to sufficiently equal their peers and the initial differences dissipate over time.

The children investigated here were 6-8 years of age. Brain maturation occurs through 12 years of age and beyond. Specifically, this maturation consists of myelination of the reticular formation and migration of neurons to the cerebral cortex with a resulting increase in density of the cortex (Adams & Victor, 1989, p. 460). It is plausible that differences between apneic and control children may be present at a later age following this brain maturation. Abstract reasoning becomes the more prominent mode of functioning during this maturation, thus, even though there are no significant differences at the current age, there could be later. However, due to the fact that differences have been found during infancy (Fisch et al., 1968; Coleman et al., 1988; Graham et al., 1962) but none were noted at 6-8 years of age, it seems unlikely that differences will be found in the future.

Another possibility which may account for the neuropsychological findings is the inadequacy of the measure utilized in this study. The K-ABC is primarily an intelligence test itself, thus the results may be more applicable to IQ. The K-ABC was used due to reported usefulness in neuropsychological assessment (Kamphaus, & Reynolds, 1987), its detection of cerebral specialization, and its appropriateness for the age range studied. This is a very broad measure of neuropsychological functioning and

may not be sensitive enough to detect specific deficits. However, there is a great deal of controversy about the usefulness of current neuropsychological tests with children 8 years of age and younger. At these ages, children tend to present very different, and suggestive profiles as compared to adults, but have very little neuropathology. This difference is primarily due to the fact that at younger ages the brain has not matured enough to allow abstract cognitive processing. Many of the tasks are constructed to assess abstract reasoning. Utilizing these tests with children tends to suggest deficits in abstract reasoning before the child has attained this level of thought. Therefore, the standard neuropsychological batteries are not commonly used with this age range. While in this study there were no differences on the K-ABC at this age, testing administered at a later age with a more sensitive neuropsychological test may, perhaps, reveal some differences.

Previous research on the behavioral profile of children who experienced anoxia was more suggestive of differences at later ages than the other measures. Specifically, Rosenfield and Bradley (1948) found behavioral differences subsequent to anoxia up to the age of 13. These findings were not supported by this research. However, the Rosenfield and Bradley (1948) study was conducted on an inpatient psychiatric population and also may be outdated. Other research (Graham, 1962; Field et al., 1978; Lasky et al., 1983; and Bendell et al., 1986) was conducted from infancy to 3 years of age. As with the other measures, these differences appear to be negligible at later ages.

Integrating the intelligence and behavioral measures, the profiles presented by the apneic children in this study do not fit the typical hyperactive profile. As described earlier, this profile tends to show normal IQ's with deficits due to inattention and impulsivity, and a lower Freedom from Distractibility score. These measures for the apneic group were not significantly different from the control subjects. Similarly, none of the apneic subjects carried a clinical diagnosis of hyperactivity. Therefore, the hypothesis that these children may represent a subgroup of the hyperactive population is not supported.

While there is no evidence that undetected differences exist, it is plausible that changes in research design may yield different results. Due to the difficulty of obtaining subjects, this research had a relatively small sample size which may have decreased the power to detect small differences. Investigation of these hypotheses with a larger sample size may be beneficial. Similarly, power was reduced due to the use of multiple comparisons. It appears, however, that regardless of the manner in which we control the Type I error rate, no significant differences will be found. This is emphasized by the fact that there were no significant differences even using the critical value for a single t test. Another possible change in design would be to use other tasks and tests have been developed since this research was conducted. These tests could more intensively assess specific abilities with this age range (e.g. memory) that might, indeed, yield significant

differences. This area of investigation remains sparse, such that it is important to replicate or refute these findings.

There are direct implications of the present study. A diagnosis of apnea during infancy does not necessarily determine later deficits in IQ, neuropsychological or behavioral functioning. While these children experience some initial immaturity or delay in these areas of functioning, based on this study they appear to develop normally over time. In this apnea population, the pauses in breathing and resulting oxygen deprivation they experienced during early infancy does not appear to cause long-lasting deficits or predictable differences. Rosenfield and Bradley (1948) reported that human infants and newborns of other species can survive severe oxygen deprivation with few resulting symptoms, unlike their adult counterparts. This research supports the notion that infants can be very resistant to this oxygen deprivation. It may also indicate that the infant brain can evidence plasticity to accommodate for an early trauma.

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APPENDIXES

APPENDIX A

CONSENT FORM

Oklahoma State University

Department of Psychology

University of Oklahoma Health Sciences Center

and Oklahoma Teaching Hospitals

I, _____, voluntarily agree for my child _____ to participate in this study entitled, "Characteristics of children who survived infantile apnea" and is sponsored by Oklahoma State University and the University of Oklahoma Health Sciences Center and Oklahoma Teaching Hospitals, under the supervision of Joan Holloway, Ph.D., Mary Anne McCaffree, M.D., and Dana Deardeuff, M.S.

Purpose:

The purpose of this research is to investigate characteristics of children who experienced infantile apnea.

Results of this study may be used for early intervention for children who experience apnea to prevent later problems in functioning. I/I hereby agree for my child to participate in this study.

Description of Study:

I understand that the interviewer(s) will gather information about me and my family, and will test my child in areas of cognitive and behavioral functioning with some standard psychological tests.

I also understand that participation will include a brief screening interview, followed at a later date by a 3-4 hour testing appointment for my child. I also understand that I will be asked to

fill out a questionnaire concerning my child's behavior which takes 15-30 minutes.

I further understand it is important for me to participate for the full investigation (screening and testing) so that complete information may be gathered, and agree to be contacted by mail, phone, or personal interview.

I will be asked to give the names, addresses, and telephone numbers of certain designated individuals who the researcher can contact to help locate me during the investigatory period of one year.

Risks:

The main risk in participating in this research is that my identity and facts about my life and my child's functioning will be known by the investigator and assistants. However, every effort and precaution will be taken to protect my privacy and confidentiality as designated in the Code of Ethics for Psychologists as specified by the American Psychological Association. Another possible risk is that I could be uncomfortable when asked about my child's history and behavior, and facts about my life and my child's. For my child, there are no unusual risks, only those that might be associated with standardized psychological testing.

Benefits:

All these results and information about me and my relatives will be kept confidential, my name will not be recorded with any of the information, and the information will only be identified by a

code number. Additionally, all data will be reported only by groups. No individual data will be reported.

The benefits of participation in this study include the knowledge that my child and I have contributed to the understanding of possible long term effects of apnea. Such understanding might lead to benefits in early intervention for these infants. Also, if I so desire I will be able to schedule a results conference with Dana L. Deardeuff, M.S. to have an interpretation of the cognitive testing my child has undergone.

In the Event of Injury:

It is clear to me that no compensation will be available from the State of Oklahoma Teaching Hospitals or their employees unless I otherwise qualify for the Hospital's health insurance or for other employee benefits. I understand that if I am so injured, medical facilities and treatment will be available to me. However, I will be required to pay a reasonable fee for such care. This does not mean that I could not receive medical benefits if otherwise entitled. I understand that if I have any questions or desire further information concerning the availability of compensation or medical care, I may contact J. Andy Sullivan, M.D., Chief of Staff at 271-4790.

Assurances:

Should I or my child experience any unusual adverse effects from this research or if I have any questions, I can contact Dr. Joan Holloway, Department of Psychology, Oklahoma State University, Stillwater, Oklahoma, 74078, (405) 744-6983, Dr. Mary Anne

McCaffree, University of Oklahoma Health Sciences Center (405) 271-5215, or Dana Deardeuff at Oklahoma State University (405) 744-6027 to discuss these concerns and/or ask any questions. If necessary I will be referred to a qualified psychologist to discuss these problems further. This referral would in no way obligate me to see a psychologist, nor would it obligate the researchers, Oklahoma State University, or Oklahoma University Health Sciences Center to pay for such. I also understand that if I have any questions concerning my legal rights as a subject, I may contact the office of University Research Services, Oklahoma State University, 001 Life Sciences East, phone number 744-9991. I may also take any questions to the Director of Research Administration, University of Oklahoma Health Sciences Center, Room 121, Library Building, telephone number 271-2090.

I have been informed of the risks and benefits and given an opportunity to ask questions. I voluntarily agree to participate in this research. I also acknowledge that I have not waived any of my legal rights or released these institutions from liability for negligence. I understand that refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled. I also understand that I am free to withdraw this consent and to discontinue my participation and my child's participation at any time without penalty or loss of benefits to which I am otherwise entitled. My treatment by, and relations with the physician(s) and staff at the University of Oklahoma Health Sciences Center and Oklahoma State University, now and in the future, will not be

affected in any way if I refuse to participate, or if I enter the program and withdraw later.

I have read this informed consent document. I understand its contents and I freely consent to participate in this study under the conditions described in this document. I understand that I will receive a copy of this signed consent form.

Mother's signature_____

Father's signature_____

Child's signature_____

Principal Investigator's signature_____

Witness signature_____

Date_____

APPENDIX B

SUBJECT IDENTIFICATION QUESTIONNAIRE

Answer the following information about your child:

Subject #_____ Sex (circle one) male female

Date of Birth_____ Age_____

Last name_____ First name_____ M.I.____

Street address_____

City_____State_____Zip_____

School child attends_____

Child's grade in school_____

Answer the following information about yourself:

Last name_____First name_____

Street address_____

City_____State_____Zip_____

Home Telephone Number_____Work_____

In order to contact you later to ask you to continue to participate in our research, please give the names and addresses of people who will probably know where you are living and how we might reach you. We will not tell them anything about the research except that you have participated in some research and agreed to be contacted later to continue to participate in this research. As stated before, all information obtained from you is strictly confidential and we will not give any information about you to anyone (which, of course, includes those whose names you give us here).

Mother's Name_____

Address_____

City_____State_____Zip_____

Telephone: Area Code_____Number_____

Father's Name_____

Address_____

City_____State_____Zip_____

Telephone: Area Code_____Number_____

Friend's Name_____

Address_____

City_____State_____Zip_____

Telephone: Area Code_____Number_____

Other relative's name_____

Address_____

City_____State_____Zip_____

Telephone: Area Code_____Number_____

Sex of Respondent: Male Female

Education Level:_____

Occupation:_____

Marital Status:_____

Spouse Information (if Applicable):

Education Level:_____

Occupation:_____

APPENDIX C

SCREENING QUESTIONNAIRE

1) Pregnancy:

Was the mother exposed to rubella or other illnesses during pregnancy?

What illness and during which trimester?

2) Perinatal Period:

What mode of delivery occurred?

Were there complications during delivery?

What was the weight of child at birth?

Was the child full-term or premature?

How early if premature?

What were the Apgar scores at birth?

Was child blue at birth or after?

Any problems during the first several months after birth, what was done?

Did baby or child ever stop breathing or go without oxygen for a period of time?

3) Developmental Milestones:

When did child sit without support?

When did child walk without support?

When did child speak single words?

When did child speak in short sentences?

When did child become fully potty trained?

4) Developmental Disorders:

Any difficulties in child's speech development?

Was child's speech comprehensible to other persons

outside the family?

Any difficulties in child's hearing?

Did child wet the bed after 3 years of age?

Did child eat materials other than food?

Did child walk in his/her sleep?

Did child have temper-tantrums?

Did child ever hold his/her breath for long periods of time?

Was child clumsy during the early years?

5) Medical History:

Any injuries to the child's head that resulted in a loss of consciousness?

Did child have seizures?

Did child have an abnormally high fever for any period of time?

Did child have recurrent ear infections?

Did child have any eye or vision difficulties?

Did child have any reactions to inoculations or vaccinations?

Did child have any unusual reactions to medications?

Did child have fainting spells?

Did child have diagnosed apneic episodes?

Has child been seen by a psychologist, psychiatrist or any other mental health worker, any diagnosis?

6) Present Status

Is the behavior of child unusual at home or at school?

Does child have any physical complaints (headaches, abdominal pain, eyestrain)?

Any medications currently being administered (prescription or over-the-counter), reason and dosage?

Has child taken any intelligence or psychological tests in the past six months, what tests?

How difficult would you say your child is to parent?

a) very difficult

b) somewhat difficult

c) not very difficult

d) not at all difficult

APPENDIX D

APNEA INFORMATION QUESTIONNAIRE

At what age was your child diagnosed apneic?

At what age was your child placed on a home monitor?

At what age was your child taken off of the home monitor?

When your child was first placed on the home monitor, approximately how many times did the alarm go off per day in the first 2 weeks?

How many times was it necessary to resuscitate your child?

Have any of the child's siblings been diagnosed with apnea?

Have any of the child's siblings been diagnosed with hyperactivity?

Did your child take any medication for the apnea? How much? How long?

Describe the events that led to the initial diagnosis of apnea.

APPENDIX E

TABLES

Table 1

DSM-III-R Diagnostic Criteria for Attention-deficit Hyperactivity Disorder

---

A. A disturbance of at least six months during which at least eight of the following are present:

1) often fidgets with hands or feet or squirms in seat (in adolescents, may be limited to subjective feelings of restlessness)
2) has difficulty remaining seated when required to do so
3) is easily distracted by extraneous stimuli
4) has difficulty awaiting turn in games or group situations
5) often blurts out answers to questions before they have been completed
6) has difficulty following through on instructions from others (not due to oppositional behavior or failure of comprehension), e.g., fails to finish chores
7) has difficulty sustaining attention in tasks or play activities
8) often shifts from one uncompleted activity to another
9) has difficulty playing quietly

(table continues)

10) often talks excessively

11) often interrupts or intrudes on others, e.g., butts into other children's games

12) often does not seem to listen to what is being said to him or her

13) often loses things necessary for tasks or activities at school or at home (e.g., toys, pencils, books, assignments)

14) often engages in physically dangerous activities without considering possible consequences (not for the purpose of thrill-seeking), e.g., runs into street without looking

B. Onset before the age of seven.

C. Does not meet the criteria for a Pervasive Developmental Disorder.

Source: American Psychiatric Association, 1987, pp. 52-53.

Table 2

Subject Characteristics

		Age		Sex		SES	
Group	n	M	SD	Male	Female	M	SD
Apneic	19	6.79	0.79	11	8	36.97	10.18
Control	19	6.63	0.68	10	9	43.32	9.39

Table 3

Scale Results for Apnea and Control Groups

Test	Sub-scale	Group	M	SD	t
WISC-R	FSIQ	Apnea	99.68	15.02	0.35
		Control	101.26	12.74	
	VIQ	Apnea	104.16	29.67	-0.52
		Control	100.37	11.84	
	PIQ	Apnea	100.53	13.82	0.28
		Control	101.79	13.90	
	VerComp	Apnea	55.20	14.78	0.33
		Control	56.67	12.44	
	Per Org	Apnea	62.72	15.28	0.27
		Control	64.00	13.86	
	FD	Apnea	59.73	15.94	0.32
		Control	61.38	15.63	
K-ABC	Seq Proc	Apnea	103.11	16.93	1.12
		Control	110.95	25.38	
	Sim Proc	Apnea	97.42	14.85	1.18
		Control	102.63	12.34	
	MPComp	Apnea	99.74	16.16	0.94
		Control	104.21	13.02	
CBCL	Internal	Apnea	57.05	8.98	-0.66
		Control	55.16	8.61	

(table continues)

Test	Sub-scale	Group	M	SD	t
CBCL	External	Apnea	57.68	11.48	-1.21
		Control	53.16	11.55	
	Soc Comp	Apnea	45.17	15.00	0.76
		Control	48.89	15.32	
	Somatic	Apnea	61.63	7.44	-1.50
		Control	58.47	5.41	
	Depression	Apnea	58.53	6.18	0.53
		Control	59.68	7.33	
	Hyperactive	Apnea	60.68	5.95	-1.11
		Control	58.11	8.16	
	Aggressive	Apnea	61.58	7.76	-0.97
		Control	59.00	8.61	
	Delinquent	Apnea	60.68	5.81	-0.30
		Control	59.89	9.87	
	Beh Prob	Apnea	58.47	10.62	-1.04
		Control	54.95	10.35	

Note. Obtained t values compared to t(36), p < .05 = 3.23, one-tailed test.

Table 4

Scale Results for More Severe vs Less Severe Apnea Groups

Test	Sub-scale	Group	M	SD	t
WISC-R	FSIQ	Sev. A	99.40	10.83	0.06
		Con. A	99.79	16.62	
	VIQ	Sev. A	102.00	8.37	0.29
		Con. A	104.93	34.57	
	PIQ	Sev. A	96.40	12.93	0.81
		Con. A	102.00	14.28	
	Ver Comp	Sev. A	59.39	11.03	-0.27
		Con. A	57.65	16.26	
	Per Org	Sev. A	60.48	11.17	1.13
		Con. A	68.00	16.40	
	FD	Sev. A	72.6	6.22	-2.47
		Con. A	59.4	17.04	
K-ABC	Seq Proc	Sev. A	104.20	20.29	-0.15
		Con. A	102.71	16.41	
	Sim Proc	Sev. A	97.00	4.80	0.11
		Con. A	97.57	17.27	
	MP Comp	Sev. A	99.60	11.22	0.03
		Con. A	99.79	17.97	
CBCL	Internal	Sev. A	58.00	7.04	-0.31
		Con. A	56.71	9.80	

(table continues)

Test	Sub-scale	Group	M	SD	t
CBCL	External	Sev. A	58.20	16.27	-0.09
		Con. A	57.50	10.05	
	Soc Comp	Sev. A	38.80	23.08	0.50
		Con. A	44.21	11.81	
	Somatic	Sev. A	62.20	7.05	-0.20
		Con. A	61.43	7.82	
	Depression	Sev. A	56.80	4.02	0.92
		Con. A	59.14	6.80	
	Hyperactive	Sev. A	62.60	7.67	-0.70
		Con. A	60.00	5.39	
	Aggressive	Sev. A	64.20	8.41	-0.83
		Con. A	60.64	7.61	
	Delinquent	Sev. A	60.60	6.27	0.03
		Con. A	60.71	5.89	
	Beh Prob	Sev. A	59.20	13.98	-0.15
		Con. A	58.21	9.77	

Note. Obtained t values compared to $t(17)$, $p < .05 = 3.64$, one tailed test.

Sev. A is the subset of 5 subjects who scored 3 or 4 on the severity of apnea measure.

Con. A is the remaining subset of 17 apneic subjects scoring 1 or 2 on the severity of apnea measure.

Table 5

Scale Results for More Severe vs Control Group

Test	Sub-scale	Group	M	SD	t
WISC-R	FSIQ	Sev. A	99.40	10.83	0.33
		Control	101.26	12.74	
	VIQ	Sev. A	102.00	8.37	-0.35
		Control	100.37	11.84	
	PIQ	Sev. A	96.40	12.93	0.82
		Control	101.79	13.90	
	Ver Comp	Sev. A	59.39	11.03	-0.48
		Control	56.67	12.44	
	Per Org	Sev. A	60.48	11.17	0.59
		Control	64.00	13.86	
	FD	Sev. A	72.6	6.22	-2.47
		Control	61.38	15.63	
K-ABC	Seq Proc	Sev. A	104.20	20.29	0.63
		Control	110.95	25.38	
	Sim Proc	Sev. A	97.00	4.80	1.59
		Control	102.63	12.34	
	MP Comp	Sev. A	99.60	11.22	0.79
		Control	104.21	13.02	
CBCL	Internal	Sev. A	58.00	7.04	-0.77
		Control	55.16	8.61	

(table continues)

Test	Sub-scale	Group	M	SD	t
CBCL	External	Sev. A	58.20	16.27	-0.65
		Control	53.16	11.55	
	Soc Comp	Sev. A	38.80	23.08	0.93
		Control	48.89	15.32	
	Somatic	Sev. A	62.20	7.05	-1.10
		Control	58.47	5.41	
	Depression	Sev. A	56.80	4.02	1.17
		Control	59.68	7.33	
	Hyperactive	Sev. A	62.60	7.67	-1.15
		Control	58.11	8.16	
	Aggressive	Sev. A	64.20	8.41	-1.22
		Control	59.00	8.61	
	Delinquent	Sev. A	60.60	6.27	-0.20
		Control	59.89	9.87	
	Beh Prob	Sev. A	59.20	13.98	-0.64
		Control	54.95	9.35	

Note. Obtained t values compared to $t(17)$, $p < .05 = 3.64$, one tailed test.

Sev. A is the subset of 5 subjects who scored 3 or 4 on the severity of apnea measure.

Table 6

Correlations of Scale Results and Severity of Apnea

Test	Sub-scale	*r*	*t*
WISC-R	FSIQ	0.10	0.40
	VIQ	-0.03	-0.14
	PIQ	-0.03	-0.11
	Ver Comp	0.10	0.43
	Per Org	-0.07	-0.28
	FD	0.40	1.77
K-ABC	Seq Proc	0.05	0.20
	Sim Proc	0.06	0.24
	MP Comp	0.05	0.19
CBCL	Internal	0.02	0.08
	External	-0.11	-0.45
	Soc Comp	-0.08	-0.32
	Somatic	-0.14	-0.59
	Depression	-0.02	-0.08
	Hyperactive	0.06	0.26
	Aggressive	0.14	0.59
	Delinquent	-0.14	-0.56
	Beh Prob	-0.06	-0.25

Note. Obtained *t* values compared to $t(17), p < .05 = 3.48$, one-tailed test.

2

VITA

Dana Deardeuff

Candidate for the Degree of

Doctor of Philosophy

Thesis: CHARACTERISTICS OF CHILDREN WHO SURVIVED INFANTILE APNEA

Major Field: Psychology

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, January 18, 1963, the daughter of D. Stanley and Joan Dearduff.

Education: Graduated from Northeast High School, Oklahoma City in 1982; received Bachelor of Science degree in Psychology from the University of Oklahoma in May, 1985; received Master of Science in Psychology from Oklahoma State University in December, 1986; completed requirements for the Doctor of Philosophy degree at Oklahoma State University in May, 1991.

Professional Experience: Intern, Cincinnati VA Medical Center, Cincinnati, Ohio, September 1989 to September 1990; Psychological Assistant, Court Psychiatric Clinic, Cincinnati, Ohio, September 1989 to September 1990; Psychological Assistant, Oklahoma Youth Center, Mental Institution for Children and Adolescents, Norman, Oklahoma, August 1988 to May 1989; Therapist, Marriage and Family Treatment Clinic, Stillwater, Oklahoma, August 1986 to August 1988; Psychological Assistant, Enid State School, Institution for the Mentally Retarded, Enid, Oklahoma, August 1986 to June 1987.

Professional Organizations: American Psychological Association, Southwestern Psychological Association, Sigma Xi Research Grant Recipient, Golden Key National Honor Society, Phi Beta Kappa.