

Predictors of Toddler Behaviors from Infant Attention Measures

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This research is supported by a National Research Initiative Grant 2008-35200-18779 from the USDA National Institute for Food and Agriculture, and the Provost's Office and College of Human Sciences at Oklahoma State University. Special thanks to Dr. David Thomas, Dr. Tay Kennedy, and Dr. Maureen Sullivan for their help in preparation of this manuscript.

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Acknowledgement

I would like to thank Dr. Thomas for his mentorship and also Oklahoma State University's Wentz foundation for their financial support for my research and academics.

Abstract

The present study focuses on infant attention and the later predictions of Attention Deficit Hyperactivity Disorder (ADHD) in toddlers. ADHD can lead to many behavioral, social, and academic problems as these children age (American Psychiatric Association, 2013), causing a gap in their development. We hypothesize that the percentage of sustained attention (SA) and/or attention termination (AT) found in infant heart rate (HR) measures will be predictive of higher scores of inattentiveness on the Child-Behavioral Checklist (CBCL). Thirty-three infants/toddlers and their mothers participated in this longitudinal study. The data was collected over a four-year span, in which HR data from the infants and CBCL data from the mothers were collected. The results did not support our hypothesis of percentage time spent in SA and/or AT being predictive of higher scores of inattentiveness. However, there were significant results in percentage of time spent in AT and higher scores of aggressive behaviors in the toddlers. This finding supports past research that ADHD in younger populations is manifested as aggressive behaviors instead of inattentiveness, which is the manifestation in older populations.

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Attention Deficit Hyperactivity Disorder (ADHD) has become an extensively studied childhood disorder, but its causes and earliest symptoms are still unknown (Alessandri, 1992; Kasper, Alderson, & Hudec, 2012; Kofler, Rapport, & Alderson, 2008). ADHD is a “persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with development, has symptoms presenting in two or more settings (e.g. at home, school, or work), and negatively impacts directly on social, academic or occupational functioning” (American Psychiatric Association, 2013). There is little research that looks at ADHD onset prior to school age, with most not looking until second grade (Deutscher & Fewell, 2001). The lack of research on ADHD prior to school age can be attributed to the fact that studies show that ADHD cannot be clinically diagnosed before school years (Alessandri, 1992; Rapport, Kofler, Alderson, & Raiker, 2007; Deutscher & Fewell, 2001). The authors also state that there could be a discrepancy between the diagnostic criteria (attention or aggression) when observing these two populations (toddlers and school age children) for ADHD. How symptoms of ADHD are expressed at different ages could be attributed to environmental differences, (Deutscher & Fewell, 2001) such as being at school and needing to pay attention to the teacher to succeed compared to being at home or in a daycare where directed attention is not necessarily expected or required to succeed. Furthermore, there is evidence that in younger samples ADHD symptoms are more closely related to aggressive behaviors than strictly lack of attention (Campbell, 1990; Campbell & Cluss, 1982; Rubin & Clark, 1983; Schleifer et al., 1975).

Although literature has indicated that attention measures in infancy are associated with later intellectual functioning (Lawson & Ruff, 2004), surprisingly few attempts have been made to use these infant measures of attention to predict later attention problems in childhood. Studying these early signs of attention problems in infants and toddlers would hopefully lead to earlier detection of ADHD. Earlier detection is needed because ADHD has become one of the most prevalent neurobehavioral disorders affecting children. Studies suggest that 3% to 5% of school-aged children in the United States have significant educational problems because of ADHD (Deutscher & Fewell, 2001). Numerous studies reveal many adverse outcomes associated with ADHD, ranging from scholastic underachievement and school failure to dysfunctional interpersonal and employment-related relationships (Rapport et al., 2007; Barkley, DuPaul, & McMurray, 1990; Goodyear & Hynd, 1992).

Findings by Richards and Casey (1992) on infant attention using HR defined phases led to our hypothesis that variations in infant attention may be related to attention deficits in childhood. Their data demonstrates that infants show a sustained parasympathetic response (heart-rate deceleration) while processing visual information. The *sustained attention* (SA) phase is defined as a deceleration in the heart rate. This phase represents the period that infants are engaged and encoding information. Richards and Casey found that visual information is encoded more efficiently during SA compared to the *orienting* (OR) and *attention termination* (AT) phases. Both the OR and AT phases are represented by an increase in heart rate. According to Richards and Casey (1992) AT involves reduced information processing and can be used as a measure of the infant’s ability to disengage their attention. Further, Ruff and her colleagues (Ruff, Capozzoli, & Weissberg, 1998; Ruff, Lawson, Parinello, & Weissberg, 1990.; Ruff, Capozzoli, & Saltarelli, 1996) found that lower percentages of sustained attention at age 1-2 years correlated with inattention at age 3.5. This information leads us to believe that by comparing infant attention measures (SA and/or AT) with later toddler attention measures from

the Child-Behavioral Checklist (CBCL), there may be evidence to identify specific infant attention measures that suggest later attention problems.

Methods

Participants

We recruited thirty-three mothers and their children from an original experimental infant group from study based on nutrition and development. All participants were recruited from the Stillwater, Oklahoma area through local breastfeeding groups, publicly posted flyers, and via word-of-mouth. The experimenters tested the infants at 3, 6, and 9 months of age and then again as toddlers. The toddlers were tested at a mean age of 3.2 years of age ($M=1174.64$ days, $SD=170.469$), and there was an even distribution of sex with a total of 15 males and 18 females. The majority of these mothers were white (86%) and well-educated (64% were college graduated). In addition, all infants had single, full-term, births without complications, and were healthy and primarily breastfed at 3 months. The Institutional Review Board of Oklahoma State University approved the study, and each mother provided informed consent for herself and for her infant/toddler.

Infant Measures

The present study used the visual information processing (Vishab) task which is an infant controlled habituation procedure to a single face stimulus (Colombo et al., 2009). The infant sat in a car seat centered 60 cm from a 43 cm X 27 cm computer screen. The experimenter dimmed the lights. The computer screen presented a randomly selected adult Caucasian expressionless human face (set against a white rectangular background of 18.5 X 14 cm) for each infant. The computer presented the face for as long as the infant was fixated on it, but removed the face when the infant looked away for one second or longer. The face was again presented after a two second interval during which the screen remained blank. The experimenter recorded the duration of each fixation in another room by observing the infant on a television screen through a video camera set above the infant's computer screen. Habituation criterion was two consecutive looks $\leq 50\%$ of the mean of the two longest looks. The computer controlling stimulus presentation also sent signals to a second computer that controlled acquisition of the electrocardiogram (EKG).

During the Vishab procedure, the experimenter measured electrocardiogram (EKG) for each infant with disposable Ag-AgCl electrodes placed in a triangular configuration on the infant's chest and abdomen. The computer digitized the EKG data at 250 Hz with a Biopac™ (BioPac Inc., Santa Barbara, CA) system that controlled data acquisition and synchronized it with the stimuli and the coding of the infant's fixations; the computer data file thus recorded these events along with the EKG.

Each infant's data file was parsed into the categories of baseline (BL), orienting (OR), sustained attention (SA), and attention termination (AT). Baseline was calculated for each fixation as the median heart rate in beats per minute for the two seconds prior to each fixation. Orienting was defined as two or more consecutive heartbeats above BL, sustained attention as five or more beats below baseline, and attention termination as two or more heartbeats above BL following SA. The durations of OR, SA, and AT were recorded as were the percentages of each of these heart-rate-defined attentional phase.

Toddler Measures

The present study used the Child-Behavioral Checklist (CBCL/ 1 ½ -5) to measure the attention of the toddlers (Achenbach & Rescorla, 2000). The CBCL is a parent-report measure of 99 child problem behaviors. It assesses the parents' descriptions of overall child problems and

disabilities, concerns about the child, and opinions of the best things about the child. The experimenter scored the problem items using a three-point Likert-type scale (0 = Not True, 1 = Somewhat True or Sometimes True, 2 = Very True or Often True). Two broadband scores of externalizing and internalizing behaviors were obtained, and T-scores above the 98th percentile were considered clinically significant. The CBCL online data log calculated individual subscale scores (e.g., Withdrawn, Sleep Problems, Attention Problems, Aggressive Behavior), and a Total Problems score. We used the total scores from attention problems (0-10) and aggressive behavior (0-38) for the analysis (higher score signifying higher attention problems and/or aggressive behavior). Internal-consistency coefficients range from .66 to .92 for the subscale scores. Achenbach and Rescorla demonstrated the validity of this instrument by using it to distinguish between referred and non-referred children.

Predictor variables were the percentage of time infants spent in each of the three HR-defined attentional phases, namely OR, SA, and AT, at 3, 6, and 9 months of age. Outcome variables were the CBCL scores for Attention Problems and Aggressive Behavior. We calculated Pearson correlation coefficients for each predictor variable-outcome variable pair.

Results

This study used data from when the infants were tested at 3, 6, and 9 months of age and again from when they were between two and a half and four years of age. The hypothesis was that the percentage of time spent in SA and/or AT would correlate with higher scores of attention problems on the CBCL. Our data did not support our hypothesis, since the results yielded no significant correlation between the infancy measures of attention and attention problems in toddlers. However, infant AT at 3 months of age came close to predicting attention problems in toddlers ($r(31) = .274, p = .068$). The switch from CBCL attention measures to aggressive behavior showed a significant predictor at 9 months of age in infant AT ($r(31) = .319, p = .035$). When we looked over the data, only 14 of our 33 participants had any time spent in AT. We ran a post-hoc correlation analysis using the 14 participants who had spent time in AT. The results showed a very significant predictor as expected at 9 months of age in infant AT for aggressive behavior in toddlers ($r(12) = .653, p = .006$). When looking at attention problems in the 14 subject sample there was an unexplained correlation at 9 months in infant OR phase ($r(12) = -.566, p = .018$). Lastly, we examined the number of looks during the visual habituation procedure at 3, 6, and 9 months of age and their possible predicting value in toddler attention. The results yielded a significant association between number of looks at 6 months of age and reported aggressive behavior in toddlers ($r(31) = -.393, p = .024$).

Discussion

This study suggests that when examining infant measures as possible predictors of ADHD in toddlers there may need to be a focus on aggressive behavior reported in toddlers in addition to that of the actual attention measures. This finding agrees with the findings from prior studies on ADHD in samples of children younger than 5 years (Campbell, 1990; Campbell & Cluss, 1982; Rubin & Clark, 1983; Schleifer et al., 1975). A proportion of young children who show aggression at very high rates is also at an elevated risk for associated symptoms of ADHD (Hay, Hudson, & Liang, 2010). Because of this, Hay et al. (2010) hypothesized that the negative associations between prosocial behavior and externalizing problems could actually be accounted for by the symptoms of ADHD, not aggression. This suggests that the presence of aggressive behavior in children is actually a symptom of ADHD. Hay et al (2010) also found that no association between aggression and pro social behavior existed when controlling for symptoms

of ADHD. In particular, they found a negative correlation with the children's symptoms of inattention/over activity and the teachers' reports of prosocial behavior (Hay et al., 2010). Therefore, since low rates of prosocial behavior are associated with lower rates of peer acceptance (Denham, McKinley, Couchoud, & Holt, 1990; Hay et al., 2010), children with activity and attention problems may be at a higher risk for peer rejection (Hay et al., 2010). This peer rejection could be the manifestation of aggression that is seen in children with ADHD, especially in the younger age groups. As mentioned in the introduction, the significance of early detection is the ability to start intervention at the earliest sign of attention problems. By identifying at risk infants/ toddlers and introducing early interventions this could aid in the gap that develops during the early school years that can lead to social and academic problems.

Further, when we examined the number of looks and the toddler's aggressive behavior, it seemed that fewer looks predicted more aggressive behavior. We suggest that since these infants were more easily distracted by outside stimuli and lacked engaged attention at the presented stimulus, this could be the manifestation of distractibility. Distractibility is often seen as a cue symptom in ADHD. Something else to be explored is that roughly half of the sample had no AT at 9 months and the aggressive measures were only significant in the AT phase. This finding could be consistent with the Richards and Casey article explaining the significance of AT. They describe it as being involved in reduced information processing and state it could be used as a measure of the infant's ability to disengage his/her attention. This could explain why AT at 9 months of age was predictive of aggressive behaviors in the toddlers. Since AT seems to measure the ability to disengage attention, and deficits in being able to regulate attention are cue symptoms in ADHD, more attention should be paid to AT measures and ADHD.

The results are to be interpreted cautiously because of the very small sample size. An increase in sample size would give this line of study a higher probability of recruiting children who will actually be clinically diagnosed with ADHD thus obtaining a better representation of the population of interest. In addition, we need to be able to test the toddlers again after 7 years of age since that is the suggested age to make a clinical diagnosis of ADHD. Nevertheless, this study suggests that early signs of ADHD may appear during the first 9 months of life. If other studies can replicate these findings then there could be evidence to support early intervention for these at risk infants and toddlers. Beginning intervention at the earliest signs of attention problems could be a major step in preventing the behavioral and social problems seen in many ADHD cases as they advance into the school years.

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