

Predictors of Toddler Behaviors from Infant Attention Measures

Jessica E. Miner

Oklahoma State University

Author Note

Jessica E. Miner, Department of Psychology, Oklahoma State University.

Jessica E. Miner is now at the Department of Psychology, The University of Oklahoma

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Correspondence concerning this article should be addressed to Jessica E. Miner, Department of Psychology, The University of Oklahoma, Norman, OK 73019-2007.

Contact: Jessica.miner@okstate.edu

Abstract

We investigated the percentage of sustained attention and/or attention termination found in infant HR measures that could be predictive of scores on the Child-Behavioral Checklist (CBCL) that pointed towards attention problems in toddlers. Thirty-three infants/toddlers and their mothers participated in this longitudinal study. The data collection for the first round of testing was during infancy where they were tested on visual habituation in response to a stimulus while an electrocardiogram (EKG) recorded their heart rate response; infants were tested at 3, 6, and 9 months of age. The next testing phase was as toddlers. We gave each parent a self-report to fill out addressing any internalizing/externalizing behavioral problems in their child. This instrument, the CBCL, is used to clinically diagnose ADHD. Our findings suggest that ADHD in younger populations manifest as aggressive behaviors instead of strictly inattentiveness which is manifested in older populations. This is thought to be because the environment used to clinically diagnose ADHD during the school aged years is different than the environment before school is introduced; therefore, ADHD may express itself differently between the two different age groups.

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Attention deficit hyperactivity disorder (ADHD) has become an extensively studied childhood disorder, but much is still unknown (Alessandri, 1992; Kasper, Alderson, & Hudec, 2012; Kofler, Rapport, & Alderson, 2008). In addition, there is little research that looks at ADHD onset prior to school age, and usually not until second grade (Deutscher & Fewell, 2001). One reason why ADHD is not studied before school age is that many studies show that ADHD cannot be clinically diagnosed before school years, but this could be because of the difference in the two environments from before school years and during (Alessandri 1992, Rapport et al., 2007, Deutscher et al., 2001). This environmental difference could have an effect on how the symptoms of ADHD are expressed (Deutscher & Fewell, 2001). Further, there is evidence that in younger samples ADHD presents as aggressive behaviors instead of strictly lack of attention. Campbell (1990), Campbell and Cluss (1982) and others (Rubin & Clark, 1983; Schleifer et al., 1975) suggest a link between hyperactive preschoolers and aggression towards peers.

The reason why earlier detection is needed is because ADHD has become one of the most prevalent neurobehavioral disorders affecting children. It is suggested that 3% to 5% (2,000,000) 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 et al., 1990; Goodyear & Hynd, 1992). However, although a substantial amount of literature has indicated that attention measures in infancy are associated with later intellectual

functioning (Lawson & Ruff, 2004), surprisingly few attempts have been made to predict attention problems from these infant measures of attention.

Hypothesizing that variations in infant attention may be related to attention and attention deficits in childhood, we examined the work done by Richards on infant attention using heart-rate defined phases. Richards' data demonstrate that infants show a sustained parasympathetic response (heart-rate deceleration) while processing visual information (Richards & Casey, 1992). This deceleration is designated as the heart-rate phase *sustained attention (SA)*, which represents the period that infants are engaged and encoding information. Richards and Casey found that during SA, visual information is encoded more efficiently compared to the other two attentional phases, *orienting (OR)* and *attention termination (AT)*, both of which are represented by an increase in heart rate and not a great deal is known of their importance. 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 his/her attention. Further, Ruff and her colleagues (Ruff & Lawson, 1998; Ruff et al., 1990; Ruff & Rothbart, 1996) found that levels of sustained attention at age 1-2 years were predictive of inattention at age 3.5. This information leads us to believe that by comparing infant attention measures with measures of attention obtained from the same children as toddlers, we may be able to identify specific measures that are predictive of later attentional problems. If this is the case, earlier intervention may be plausible, thus potentially decreasing the adverse outcomes these individuals often endure once the school years begin. The percentage of sustained attention and/or attention termination found in the infant HR measures will be the predicting factors for

the scores on the Child-Behavioral Checklist (CBCL) that point towards attentional problems in toddlers.

Methods

Participants

One hundred thirty-two breastfeeding mothers and their infants participated in a study of nutrition and development. Thirty-three of those dyads returned when the children were toddlers for the present study. The infants were originally tested at 3, 6, and 9 months of age and then again as toddlers ranging in age from 2.5 -4 years of age. 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 from the larger study were white (86%) and well-educated (64% were college graduates or had done post-graduate study). In addition, all infants had single, full-term, non-complicated births and were healthy and primarily breast fed at 3 months. The study was approved by the Institutional Review Board of Oklahoma State University and each mother provided informed consent for herself and for her infant/toddler.

Infant Measures

We 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. Lights were dimmed. A single adult Caucasian expressionless human face (set against a white rectangular background of 18.5

X 14 cm) randomly selected for each infant was presented on the computer screen. The face remained as long as the infant fixated it but was removed if he/she looked away for one second or longer. After a two second interval during which the screen remained blank, the face was again presented. The duration of each fixation was recorded by an experimenter in another room who observed 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 electrocardiogram (EKG) was measured from each infant with disposable Ag-AgCl electrodes placed in a triangular configuration on the infant's chest and abdomen. EKG data were digitized at 250 Hz with a BiopacTM (BioPac Inc., Santa Barbara, CA) system that controlled data acquisition and synchronized it with 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 then analyzed such that each look toward the stimulus 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/minute for the two seconds prior to each fixation. Orienting was defined as two or more consecutive heart beats *above* BL, sustained attention as five or more beats *below* baseline, and attention termination as two or more heart beats above BL *following* SA. The duration of

OR, SA, and AT were recorded as were the percentages of each of these heart-rate-defined attentional phases.

Toddler Measures

We used the Child-Behavioral Checklist (CBCL/ 1 ½ -5; (Achenbach & Rescorla, 2000) for our measure of attention on the toddlers. The CBCL is a parent-report measure of 99 child problem behaviors. It assesses the parents' descriptions of overall child problems and disabilities, parents' concerns about the child, and parents' views of the best things about the child. Problem items are scored using a 3-point Likert-type scale (0 = Not True, 1 = Somewhat True or Sometimes True, 2 = Very True or Often True). Two broad-band scores of Externalizing and Internalizing behaviors are obtained, and T-scores above the 98th percentile are considered clinically significant. Individual subscale scores (e.g., Withdrawn, Sleep Problems, Attention Problems, Aggressive Behavior), and a Total Problems score are also calculated. We used the total scores from attention problems (0-10), aggressive behavior (0-38), and attention deficit/hyperactivity problems (0-12). Internal-consistency coefficients range from .66 to .92 for the subscale scores. Validity of this instrument has been demonstrated by distinguishing between referred and non-referred children (Achenbach & Rescorla, 2000).

Results

Thirty-three infants from Oklahoma were included in our data analyses. Data was used from when the infants were tested at 3, 6, and 9 months of age and again from when they were between 2.5-4 years of age. There were no significant predictors in infancy measures of attention problems or ADHD problems in toddlers. However, infant AT at 3 months of age came

close to predicting attention problems in toddlers ($r = .274, p = .068$). The switch from CBCL attention measures to aggressive behavior showed a significant predictor at 9 months of age in infant AT ($r = .319, p = .035$). When looking over the data, we found that only 14 of our 33 actually had any time spent in AT. Therefore, we followed up by running the 14 through the correlation analyses. We found a very significant predictor as expected at 9 months of age in infant AT for aggressive behavior in toddlers ($r = .653, p = .006$). When looking at attention problems in our 14 subject sample we found an unexplained correlation at 9 months in infant OR phase ($r = -.566, p = .018$). We also examined at number of looks during the visual habituation procedure at 3, 6, and 9 months of age and their possible predicting value in toddler attention. We found a significant association with number of looks at 6 months of age and reported aggressive behavior in toddlers ($r = -.393, p = .024$).

Discussion

This study suggests that when examining infant measures as possible predictors of ADHD in toddlers we may need to focus on aggressive behavior reported in toddlers in addition to of the actual attention measures. This finding agrees with the findings from prior studies on ADHD in a sample 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 are also at an elevated risk for associated symptoms of ADHD (Hay, Hudson, & Liang, 2010). Because of this, Hay, Hudson, and Liang (2010) hypothesize that the negative associations between pro-social behavior and externalizing problems could actually be accounted for by the symptoms of ADHD, not aggression. This is saying that the

presence of aggressive behavior in children is actually a symptom of ADHD. Hay et al. supported their hypothesis when they controlled for symptoms of ADHD, they no longer found a significant association between aggression and pro-social behavior. In particular, the children's symptoms of inattention/overactivity were negatively correlated with the teachers' reports of pro-social behavior (Hay, Hudson, & Liang, 2010). Therefore, since low rates of pro-social behavior are associated with lower rates of peer acceptance (Denham, McKinley, Couchoud, & Holt, 1990; Hay, Hundson, & Liange, 2010), children with activity and attention problems may be at a special risk for peer rejection (Hay, Hudson, & Liage, 2010). This peer rejection could be the manifestation of aggression that we see in children with ADHD, especially in the younger age groups.

In addition to our aggression findings, when examining looks and toddlers aggressive behavior, it seems that fewer looks predicted more aggressive behavior. This could be the representation of distractibility. In addition, roughly half of our sample had no AT at 9 months and the aggressive measures were only significant in the AT phase is something else to be explored. This finding could be in line with Richards and Casey (1992) article explaining the significance of AT. Richards et al. describe it as being involved in reduced information processing and say 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.

Given our very small sample size the results are to be interpreted cautiously. There are many possible variables that could have affected our results. We would need a larger sample and to be able to test the toddlers again after 5 years of age to even begin to draw a solid conclusion over possible infant measures as predictors of ADHD. Nevertheless, this study suggests that early signs of ADHD may appear during the first few months of life. If these findings can be replicated, then we have possibly drawn a potential starting point for early intervention. Beginning intervention at the earliest signs of attention problems could be a major step in preventing the behavioral problems seen in many ADHD cases as they advance into the toddler years and onward.

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