Developmental Cognitive Neuroscience 19 (2016) 144–151

Contents lists available at ScienceDirect

Developmental Cognitive Neuroscience

journal homepage: http://www.elsevier.com/locate/dcn

Associations among family socioeconomic status, EEG power at birth, and cognitive skills during infancy

Natalie H. Brito[a,*], William P. Fifer[a,b,c], Michael M. Myers[a,b,c], Amy J. Elliott[d,e,f], Kimberly G. Noble[g]

[a] *Division of Developmental Neuroscience, New York State Psychiatric Institute, New York, NY, United States*
[b] *Department of Psychiatry, Columbia University Medical Center, New York, NY, United States*
[c] *Department of Pediatrics, Columbia University Medical Center, New York, NY, United States*
[d] *Community & Population Health Sciences, Sanford Research, Sioux Falls, SD, United States*
[e] *Department of Pediatrics, Sanford School of Medicine at the University of South Dakota, Sioux Falls, SD, United States*
[f] *Department of Obstetrics & Gynecology, Sanford School of Medicine at the University of South Dakota, Sioux Falls, SD, United States*
[g] *Department of Biobehavioral Sciences, Teachers College Columbia University, New York, NY, United States*

ARTICLE INFO

Article history:
Received 4 December 2015
Received in revised form 9 March 2016
Accepted 9 March 2016
Available online 14 March 2016

Keywords:
EEG
Socioeconomic status
Language
Memory
Infancy

ABSTRACT

Past research has demonstrated links between cortical activity, measured via EEG power, and cognitive processes during infancy. In a separate line of research, family socioeconomic status (SES) has been strongly associated with children's early cognitive development, with socioeconomic disparities emerging during the second year of life for both language and declarative memory skills. The present study examined associations among resting EEG power at birth, SES, and language and memory skills at 15-months in a sample of full-term infants. Results indicate no associations between SES and EEG power at birth. However, EEG power at birth was related to both language and memory outcomes at 15-months. Specifically, frontal power (24–48 Hz) was positively correlated with later Visual Paired Comparison (VPC) memory scores. Power (24–35 Hz) in the parietal region was positively correlated with later PLS-Auditory Comprehension language scores. These findings suggest that SES disparities in brain activity may not be apparent at birth, but measures of resting neonatal EEG power are correlated with later memory and language skills independently of SES.

Contents

* Corresponding author at: Columbia University Medical Center, 1051 Riverside Drive, Room 4919-C, New York, NY 10032, United States.
E-mail addresses: nhb2111@cumc.columbia.edu (N.H. Brito), wpf1@cumc.columbia.edu (W.P. Fifer), mmm3@cumc.columbia.edu (M.M. Myers), amy.elliott@sanfordhealth.org (A.J. Elliott), kgn2106@tc.columbia.edu (K.G. Noble).

http://dx.doi.org/10.1016/j.dcn.2016.03.004

1. Introduction

Research using electroencephalography (EEG) as a measure of neurophysiology during infancy and early childhood has increased in recent years and studies have utilized EEG techniques to examine both generalities and individual differences in early cognitive development. In typically developing children there is a developmental decrease in EEG power of low-frequency rhythms (e.g., delta and theta) and an increase in high-frequency rhythms (e.g., beta and gamma) across age (Matousek and Petersen, 1973; Harmony et al., 1990). Relative to typically developing children, children with learning or attention disorders often demonstrate higher levels of low-frequency power and lower levels of high-frequency power (Barry et al., 2003). This atypical EEG profile has also been found in children who were previously institutionalized (Marshall et al., 2004) and children growing up in economically disadvantaged environments (Harmony et al., 1990; Otero et al., 2003; Tomalski et al., 2013).

Growing up in a socioeconomically disadvantaged environment is associated with substantially worse health and impaired psychological, cognitive, and emotional development throughout the lifespan (McLoyd, 1998; Bradley and Corwyn, 2002; Adler and Rehkopf, 2008). Childhood socioeconomic status (SES), typically characterized by parental educational attainment, family income and parental occupation (McLoyd, 1998), is strongly associated with later cognitive development and academic achievement (Bradley et al., 2001; Brooks-Gunn and Duncan, 1997; Evans, 2004; Hoff, 2003; McLoyd, 1998). In contrast to investigations examining associations between childhood SES and general intelligence or global measures of cognitive development, a number of more recent studies have adopted a cognitive neuroscience approach to understanding SES differences in cognition (Hackman and Farah, 2009; Raizada and Kishiyama, 2010; Brito and Noble, 2014). These studies measured associations between SES and specific neurocognitive systems and have reported SES-related differences in child language (Farah et al., 2006; Noble et al., 2007, 2005), memory (Farah et al., 2006; Noble et al., 2007, 2005), and executive functions (Farah et al., 2006; Kishiyama et al., 2009; Lipina et al., 2005; Stevens et al., 2009).

Recently, Noble and colleagues (2015) reported socioeconomic disparities in both language and declarative memory emerging between 15 and 21 months of age. Both language and memory show individual differences in developmental trajectories in the first two years of life (Barr et al., 1996; Barr and Brito, 2013; Halle et al., 2009) and these skills are predictive of later cognitive development (Bornstein and Sigman, 1986; Fagan and Singer, 1983; Halle et al., 2009; Hoff, 2003). Findings from Noble et al. (2015) were consistent with past work demonstrating socioeconomic disparities in early language skills by the age of two (Fernald et al., 2013; Halle et al., 2009; Hoff, 2003; Rowe and Goldin-Meadow, 2009), and extended work on SES disparities to declarative memory skills during infancy.

Although behavioral paradigms assessing specific cognitive skills have reported SES disparities in the second year of life, SES differences in resting EEG have been reported as early as 6–9 months of age (Tomalski et al., 2013). In a sample of 45 full-term infants, Tomalski and colleagues measured resting EEG power of infants from higher and lower-SES households based on family income and parental occupation. Parental education was not used as a predictor as the sample was relatively well educated. Infants were split into SES groups by median family income and occupational group status. Researchers examined two gamma frequencies (21–30 Hz and 31–45 Hz) from four scalp areas (frontal, left temporal, right temporal, and occipital) and reported significantly reduced frontal low-gamma (21–30 Hz) power in infants from lower SES families. The associations between EEG power and SES were not explained by infant sex, age at testing, parental education, breastfeeding, exposure to smoke, or quality of infant sleep (Tomalski et al., 2013). In children, gamma power increases across age, particularly in the frontal regions of the brain (Takano and Kgawa, 1998), and differences in frontal gamma power have been related to language and cognitive skills in toddlers (Benasich et al., 2008) and preschoolers (Gou et al., 2011). In a sample of 63 toddlers, Benasich and colleagues (2008) found associations between individual differences in the distribution of resting frontal gamma power (31–50 Hz) and both concurrent language (Preschool Language Scale: PLS-3) and cognitive scores (Bayley Scales of Infant Development: BSID-II; Stanford-Binet Intelligence Scale—4) during the 2nd year of life (Benasich et al., 2008).

Two recent prospective studies have investigated the association between resting EEG power and later cognitive development. In a follow-up to the Benasich et al. (2008) study, children with resting EEG data at 16, 24, and 36 months of age were tested on measures of general cognitive ability and language skills at 4 and 5 years of age. Results indicated significant correlations between resting EEG gamma power and individual differences in language and cognition during preschool years (Gou et al., 2011). Additionally, Williams et al. (2012) reported significant correlations between resting EEG power at birth and 18-month Bayley cognitive scores (BSDI-III) in 13 full-term infants born with congenital heart disease (CHD). Although Bayley cognitive scores were below average in this high-risk group, higher power in the frontal regions in the beta (12–24 Hz), low-gamma (24–35 Hz), and higher-gamma (36–48 Hz) frequencies were significantly associated with higher cognitive scores at 18-months of age (Williams et al., 2012).

Given that resting EEG power has been associated with both SES disparities during the first year of life and neurocognitive skills in the second year of life, the current prospective study examined the associations between neonatal EEG power, family SES, and neurocognitive skills at 15-months of age. As SES differences in resting EEG power have been reported as early as 6–9 months (Tomalski et al., 2013), it was hypothesized that SES disparities would explain differences in neonatal EEG power and that these differences in early electrocortical activity would be associated with both language and declarative memory skills during the second year of life.

2. Method

2.1. Participants

All participants were selected from a subset of infants participating in a large, longitudinal study investigating the relation between prenatal exposures and birth outcomes (http://safepassagestudy.org; Dukes et al., 2014). The present study took place at a single participating clinic site in an urban Midwest community. Children were enrolled without regard to prenatal exposures. The present study was not powered to detect effects of these exposures; further, at the time of this writing, investigators remained blind to