



Executive function is associated with social competence in preschool-aged children born preterm or full term



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ABSTRACT

Background: Executive function (EF), defined as higher-order cognitive processes used in planning and organizing actions and emotions, is often impaired in children born preterm. Few studies have assessed social competence, the processes and resources required to meet social demands and achieve social goals, in children born preterm. The relations between EF and social competence in preterm and full term preschoolers have not been well characterized.

Aims: To characterize social competence and assess the relationship between EF and social competence in preschool-aged children born preterm or full term.

Study design: Cross-sectional study.

Subjects: Study subjects had a history of preterm birth (≤ 34 weeks of gestation) and birth weight < 2500 g ($n = 70$). Controls were born full term (≥ 37 weeks) ($n = 79$).

Outcome measures: Children completed a battery of EF tasks; a mean age-adjusted z-score for the battery was generated for each child. Parents rated child EF on one scale and child social competence on two standardized scales.

Results: Compared to full term children, preterm children showed a lower mean EF battery z-score, poorer parent-rated EF, and poorer scores on the two social competence scales. In hierarchical multiple regression models, EF battery z-score and parent-rated EF made independent contributions to both measures of social competence. Preterm birth explained additional variance for one measure of social competence.

Conclusions: Standard assessment of EF skills and social competence in young preschool children, including children born preterm, may identify at-risk children for long-term social difficulties and may also provide targets for intervention.

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1. Introduction

Executive function (EF) has been defined as “higher-order cognitive processes involved in the self-regulation of thought, action, and emotion” ([1] page 1). EF is necessary for purposeful, goal-directed activity [2]. The EF skills that are developing in the preschool-aged child include inhibitory control, set shifting, planning and working memory [3–6]. Deficits in EF are seen in young child clinical populations, such as children with histories of prematurity [4,5,7,8], attention-deficit/hyperactivity disorder (ADHD) [4,9], aggression [2] or brain injury [10]. Poor EF skills are related to difficulties in important areas of function, including cognitive and academic domains [2,11]. It also has been proposed

that poor EF has a role in social problems, from early childhood onward. However, published studies have focused on general social skills [1,12], and are challenging to interpret as they measure a wide variety of psychosocial constructs spanning cooperative behavior and social functioning.

Social competence is one important facet of children's social-emotional development [1]. Social competence can be defined as “active and skillful coordination of multiple processes and resources of the child to meet social demands and achieve social goals in a particular type of social interaction (e.g., parent–child, peer relations) and within a specific context (e.g., home, school)” ([13], page 13). Social competence emerges gradually through childhood and adolescence and reflects a dynamic interplay between the individual and his/her environment [14]. Social competence can be assessed using child interviews, direct observations, or parent and teacher questionnaires [15–20]. Social competence has important implications for public health from infancy to adulthood because it is associated with mental health, academic performance, and work place functioning [19,21].

Studies of children born preterm have shown increased likelihood of adverse developmental, cognitive, and behavioral outcomes [4,5,7,8,22–24]. Further, researchers have shown that, compared to

Abbreviations: BRIEF, Behavior Rating Inventory of Executive Function; BW, birth weight; EF, executive function; GA, gestational age; GEC, Global Executive Composite; SCBE, Social Competence and Behavior Evaluation; SD, standard deviation; SES, socioeconomic status.

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peers born at term, youth born preterm have greater difficulty with social relationships [22,25,26]. However, very few studies have specifically assessed the social competence of children born preterm [27,28], particularly at young ages. Studies have shown that EF contributes to social outcomes in older preterm children [29,30]. Studies of typically developing young children suggest that emerging EF skills may facilitate children's social competence [1,3,11]. An understanding of the associations of EF and social competence in young preschool children born preterm might inform intervention strategies to improve their EF and social competence early in life. The overall goal of this study was to determine if EF skills play a role in the social competence of preschool-aged children born preterm.

Sociodemographic factors, such as socioeconomic status and age, may also affect the development of both social competence and EF. Socioeconomic status (SES) has been associated with a wide array of socioemotional, cognitive, and health outcomes in childhood [31], including preterm birth [32]. Poor EF skills have been associated with economic disadvantage in children [33,34]. A longitudinal study of preterm and full term children followed from birth to thirty-six months showed that higher SES was predictive of better cognitive and social development for all children [35]. Age is another important factor in the development of social competence and EF as both typically improve from childhood through adolescence [36].

1.1. Study objective and hypotheses

The objective of our study was to characterize the relationship between EF and social competence in preschool-aged children who were born preterm or full term. We previously have demonstrated EF differences between full term and preterm children [37]. In this study, we focused on children born preterm as a model of biomedical risk for both impairments in EF and problems in social competence. We had three main hypotheses. Hypothesis 1 addresses social competence differences between full term and preterm children: Compared to full term children, preterm children show poorer parent-rated social competence. Hypothesis 2 addresses links between EF and social competence in both preterm and full term children: EF, whether assessed using performance-based measures or parent rating, is associated with social competence. These associations persist after controlling for maternal education and child age. Hypothesis 3 addresses contributions of preterm birth to social competence: Given the increased risk of adverse outcomes in children born preterm, gestational group contributes additional variance, beyond the effect of EF, to social competence.

2. Methods

2.1. Participants

Participants were 3- to 5-year-old children recruited from Palo Alto, CA, and surrounding counties. Gestational age (GA), birth weight (BW), and medical complications were gathered from parent report and medical records. Study subjects had a history of preterm birth (≤ 34 weeks of gestation) and BW < 2500 g ($n = 70$). Controls were born full term (≥ 37 weeks) and had no major medical complications ($n = 79$). Exclusion criteria for all participants included sensory impairments (i.e., blind or deaf), identified genetic syndrome or congenital heart disease, and inability to comprehend task instructions.

The study population consisted of a convenience sample of children born from 2004 to 2009. Preterm subjects were recruited by letters sent to families of children who were evaluated at High Risk Infant Follow-up Services at Lucile Packard Children's Hospital Stanford in Palo Alto, CA, and by postings on local parent message boards. Control children were recruited by postings on parent message boards, by flyers in general pediatric clinics, and by word of mouth. Controls were group-matched to children born preterm for age, gender, ethnicity, and race. The study was approved by the Stanford Institutional Review Board. A

parent or legal guardian provided informed consent. Participants were compensated for participation.

2.2. Procedure

Parents completed a demographic questionnaire and standardized EF rating scales. Children completed a battery of EF tasks that were administered by trained research assistants. Parents also completed two standardized measures of social competence.

2.3. Measures and variables

2.3.1. Demographics and health information

A demographic and health questionnaire collected information addressing child age, gender, ethnicity, race, and school participation (attending daycare, preschool, or kindergarten). Maternal education (< 4 years in college, 4 years in college, \geq Master's degree) was used as an indicator of SES for this relatively high SES population. Health information included gestational age at time of delivery (preterm ≤ 34 weeks of gestation; full term ≥ 37 weeks of gestation), birth weight, and medical conditions. Information concerning receipt of early intervention services also was collected.

2.3.2. Performance-based EF

Tasks were selected to represent core EF constructs based on the developmental literature on EF in typical and preterm preschoolers [4,5,38]. Children completed a behavioral battery of EF tasks that included:

1. Three- and six-box tasks, a measure of working memory and planning. Six stationary boxes with different color lids are baited with a treat in view of the child. The child's task is to efficiently find all treats by keeping track of the boxes that have already been searched. The dependent variable was the total number of reaches to find all treats.
2. Day/night task, a measure of complex response inhibition. The child should respond "night" when shown a picture of the sun and "day" when shown a picture of moon and stars. The task requires the inhibition of a prepotent verbal response in the presence of competing visual information. The dependent variable was the number of correct responses reverse scored by subtracting the number of practice trials.
3. Bird/dragon task, a modified Simon says task, a measure of complex response inhibition and working memory. The child must hold a rule in mind and respond while inhibiting a prepotent response. The dependent variable was the number of correct responses reverse scored by subtracting the number of practice trials.
4. Dimensional change card sort, a measure of cognitive flexibility/task switching and attention shifting. The child is shown cards depicting colored shapes that can be sorted by color or shape. The child must sort according to one dimension and then shift to sort according to the other dimension. The dependent variable was the number of correct responses on the post-switch phase.
5. Verbal fluency task, a measure of verbal productivity with language and organizational components. The child is asked to generate as many words as possible within specific categories (i.e., animals, foods) in one minute. The dependent variable was the total number of words that were unique and correct (belongs to the category).

We have reported on the differences between preterm and full term groups on each of these tests, with a detailed description of the tasks [37]. We converted continuous outcome measures from the performance-based EF tasks to z-scores derived from performance (mean, SD) of full term subjects in the three age groups of 3, 4, and 5 years. As outlined in the original study, we found significant small to moderate correlations among all performance-based EF measures [37]. Given the correlations among the tasks, for our analyses, we used an average z-score for the five EF tasks as a summary measure of child EF performance.

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