Bilingualism as a Potential Strategy to Improve Executive Function in Preterm Infants: A Review

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ABSTRACT

Preterm birth is associated with long-term deficits in executive functioning and cognitive performance. Using the model of brain plasticity as a theoretical framework, it is possible that preterm infants' neurodevelopmental sequelae can be altered. Evidence suggests that bilingualism confers cognitive advantages on executive functioning, so it is possible that bilingualism may improve preterm infants' neurodevelopment. However, bilingualism has only been studied in term children. This review examined literature that compared the performance of preterm-born children to term children and bilingual children to monolingual children on executive function tasks. To address cognitive disparities in preterm-born children, studies investigating the effect of bilingualism on preterm infants' executive functioning is warranted. J Pediatr Health Care. (2015) *29*, 126-136.

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KEY WORDS

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Preterm birth, defined by the World Health Organization as birth occurring at less than 37 completed gestational weeks, is a key determinant of infant health outcomes and affects 12% of all birth outcomes (Blencowe et al., 2012). Despite improvements in maternal and infant health, preterm birth is increasing in almost every country for which data are available (Blencowe et al., 2012). Shortened gestation predisposes preterm infants to a variety of health, behavioral, and developmental problems, as evidenced through studies that show higher rates of chronic disease, cognitive deficits, poor educational achievement and attainment, and disabilities among individuals born preterm (Lapillonne & Griffin, 2013; Roggero, Gianni, Garbarino, & Mosca, 2013; Williams et al., 2013).

Although advances in neonatal care have resulted in improved survival for preterm infants, the 25% to 50% prevalence of neurodevelopmental disabilities in surviving children represents a growing public health concern (Volpe, 2001). Neuropsychological testing reveals that persons born preterm perform more poorly on measures of executive function than do those born at term (Aarnoudse-Moens, Smidts, Oosterlaan, Duivenvoorden, & Weisglas-Kuperus, 2009; Baron, Kerns, Muller, Ahronovich, & Litman, 2012; Caravale, Mirante, Vagnoni, & Vicari, 2012; Cserjesi et al., 2012; Edgin et al., 2008; Kerstjens et al., 2011; Nosarti et al., 2007; Odd, Emond, & Whitelaw, 2012). Executive functions refer to multiple cognitive processes that control thoughts and behaviors, including information processing, inhibitory control, memory,

attention, cognitive flexibility, problem solving, and planning. These processes are responsible for cognition, behavior, emotional control, and social interaction, all of which underlie educational achievement (Aarnoudse-Moens et al., 2009).

Preterm infants are susceptible to poor neurodevelopmental outcomes for numerous reasons. Preterm birth is associated with high rates of perinatal brain injuries that compromise later neurological function (Darcy Mahoney & Pinto-Martin, 2012). Preterm infants are subsequently put at higher risk as the result of noxious stimuli in the neonatal intensive care unit and hypoxia due to lung immaturity. Furthermore, a major risk for poor neurodevelopmental outcomes is interruption of structural differentiation and rapid growth in the brain that occurs in the third trimester (Pickler et al., 2010). Brain volume increases nearly three-fold between the gestational age of 29 weeks and 40 weeks (Huppi et al., 1998). In other words, infants born at less than 29 weeks' gestation have only one third the brain volume as term infants. Remarkably, infants born at 35 weeks, who have historically been considered low risk, have only two thirds the brain volume of infants born only 5 weeks later (Huppi et al., 1998). Studies have suggested that decreased brain volume persists throughout childhood and correlates with measures of IQ and executive functioning (Peterson et al., 2003). Given that the prefrontal cortex, which governs executive functions, matures during the last 2 months of gestation, preterm infants are particularly vulnerable to deficits in executive functioning (Pickler et al., 2010). These deficits are most prevalent and severe among children born extremely preterm (< 28 weeks) and very preterm (28 to 32 weeks), and increasing evidence demonstrates that school performance, use of special education services, and measures of executive functioning are inversely related to gestational age (Vohr, 2013; Williams et al., 2013). As a result, all children born preterm, regardless of gestational age, are at increased risk for poor executive functioning.

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Current evidence reveals that bilingualism may enhance cognitive outcomes in children through improving executive functioning (Akhtar & Menjivar, 2012). Bilingual children consistently outperform monolingual peers on tests measuring inhibitory control, memory, awareness, conflict management, attention, and cognitive flexibility (Akhtar & Menjivar, 2012). To date, only one study has examined the effects of bilingualism on preterm infants. Walch, Chaudhary, Herold, and Obladen (2009) assessed the influence of parental bilingualism on scores on the Griffiths Scale of Infant Development at 6 and 12 months and on the Bayley Scales of Infant Development at 22 months for very low birthweight infants. Although this study found that very low birth weight infants raised in monolingual households scored one standard deviation higher than those from bilingual households, these effects could not be separated from socioeconomic status because monolingual families in this study were more highly educated than were bilingual families, and family income and verbal interaction between the parent and child were not controlled (Walch et al., 2009). In addition, this study did not assess bilingual language abilities of the child, but rather examined the influence of exposure to two languages from birth (Walch et al., 2009).

This article seeks to explore the relationships among bilingualism, prematurity, and executive functioning through the following aims: (a) review literature about preterm infants' executive functioning; (b) review literature comparing monolingual and bilingual children's performance on tasks of executive function; and (c) provide a theoretical framework for research involving bilingualism as a means to enhance executive functioning in children born preterm.

REVIEW OF THE LITERATURE

Two separate comprehensive literature searches were conducted using the databases PubMed, Web of Science, and Cumulative Index to Nursing and Allied Health Literature. One search was conducted to identify literature that examine executive functioning of children born preterm, while the other search sought to identify literature that investigated the effect of bilingualism on children's executive function. Search terms and inclusion/exclusion criteria for each search are provided in Table 1. The searches were limited to articles written in English published between 2003 and 2013 to obtain the most recent publications. Additional articles were identified from the reference lists of selected articles.

Executive Function and Prematurity

Preterm birth confers risk for cognitive, behavioral, and academic difficulties. Executive functioning deficits are prominent and may be the underlying mechanism responsible for poorer academic achievement in children born preterm (St Clair-Thompson & Gathercole, 2006). Evidence suggests that preterm birth is a risk factor for impairment across all executive domains, despite controlling for IQ differences (Aarnoudse-Moens et al., 2009; Caravale, Tozzi, Albino, & Vicari, 2005). These deficits likely have long-term social and academic implications for the preterm population.

Inhibitory control

Inhibitory control refers to the ability to selectively attend to stimuli (St Clair-Thompson & Gathercole,