

Bridging the gap between advantaged and disadvantaged children: Why should we be concerned with executive functions in the South African context?

Abstract

Reducing the economic and social burden associated with poor academic achievement represents an urgent concern in South Africa. Increasingly research suggests that child characteristics in kindergarten play an important role in charting courses towards academic success and educational attainment by early adulthood. Although math and reading skills are important predictors of later achievement, executive function skills which underlie children's ability to focus attention and become autonomous, self-directed learners also play a key role in later adjustment to school. Disadvantaged children perform more poorly on tests of achievement and executive functions. Furthermore, executive functions have been found to partially account for the relationship between socioeconomic status and later achievement. It is possible to target executive functions in at-risk children using specific interventions. These programs are generally cost-effective. It is proposed that increasing efforts towards promoting executive functions in preschool-aged children represents a promising strategy for reducing economically based disparities in the education and eventual life chances of individuals.

Keywords: School readiness, academic achievement, executive functions, socioeconomic status, preschool interventions

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South African Journal of Childhood Education | 2014 4(1): 156-166 | ISSN: 2223-7674 | © UJ

Introduction

Poor achievement and high school dropout represent urgent social concerns in both developed and developing countries. In particular, poor educational achievement in a population is associated with reductions in a country's human capital formation (Heckman 2007). On an individual basis, poor academic attainment undermines personal success, health, well-being, and ultimately reinvestment in society (Card, 1999; Heckman, 2007; Shonkoff, 2011; Woolf, Johnson, Phillips & Philpsen, 2007). In North America, the average lifetime cost to society per high school dropout is estimated at over 150 000 American dollars. There are several reasons for this. Youth who drop out of high school go on to pay on average three times less taxes over their lifetime and require and use more social services (Bowlby 2005). Individuals who are less successful in school also tend to suffer more health problems because they engage in more risky health-related behaviours (Freudenberg & Ruglis 2007). Consequently, on a national level, the cost to the medical system of a high school dropout is on average three times greater than that of an individual who persists to high school completion. Furthermore, poorly educated individuals are more likely to be involved in and arrested for crimes, which incur further costs on the justice system. For these reasons, economists estimate that increasing graduation rates would therefore translate into substantial savings in the criminal justice system. Given the high human and economic cost of underachievement, the prevention of academic failure and dropout has become important from a social policy standpoint.

School readiness

Promoting children's readiness to learn at kindergarten may represent one of the most efficient ways to decrease dropout and the important social costs it engenders. Research has shown that the process leading up to high school dropout does not emerge in high school, but rather can be traced all the way back to kindergarten (Alexander, Entwistle & Horsey, 1997; Entwistle, Alexander & Olson, 2005). This finding has led to an increased interest in school readiness, which refers to child cognitive, psychosocial, and physical preparedness to meet the challenges of the classroom at the time of school entry (High, 2008; Zuckerman & Halfon, 2003). Inherent in the concept of school readiness is the idea that if we can somehow make sure children are well-prepared to learn by the time they begin first grade, we can prevent them from falling behind, and set them off on a trajectory of academic success.

Not all children arrive at school equally well prepared to learn on the first day of class (Duncan, Brooks-Gunn, Dowsett, Claessens, Huston, Klebanov, Magnuson, Huston, Klebanov, Pagani, Feinstein, Engel, Brooks-Gunn, Sexton, Duckworth & Japel, 2007; High, 2008). As a result, research on school readiness has several important areas of application. First, developing empirically validated early assessments of child skills that predict later achievement allows us to better identify children who run the risk of experiencing later academic difficulty. Second, school readiness research has shed light on the relative importance of different academic skills to later child

achievement. Finally, research which has examined how school readiness skills predict success above and beyond socioeconomic and family factors helps inform the development of interventions that are likely to be effective with children facing socio-demographic risk.

One of the most important studies of school readiness was conducted by Duncan et al (2007). Methodologically, this piece represents a benchmark for school readiness research because of its large sample size and rigorous control of potentially confounding variables. This study followed over 36 000 children from six longitudinal data sets in Canada, the United States and the United Kingdom. The authors examined a comprehensive set of kindergarten school readiness indicators including child intellectual (math and reading skills) and behavioural characteristics (attentiveness, internalising and externalising problems, and social skills) to assess which skills would be most predictive of children's academic success in the second grade.

Remarkably, the results were consistent across all six longitudinal data sets. Kindergarten number knowledge was the strongest and most consistent predictor of later achievement in both math and reading, followed by early reading skills and attention skills. When a meta-analysis was conducted on the pooled data sets, the results remained robust. The inclusion of a large number of control variables in this study helped researchers estimate the unique and relative importance of school readiness skills, above and beyond a number of potentially confounding child and family characteristics. Results revealed that the associations observed in Duncan's study could not be accounted for by child ethnicity, sex, age, birth weight, maternal language or number of siblings. Nor were they explained by maternal age, education, depressive symptoms, parental aspirations for their child's education, socioeconomic status, presence of children's books in the home, neighbourhood quality or children's enrolment in daycare. In sum, children's kindergarten math, reading and attention skills predicted achievement two years later regardless of the types of homes children came from.

Surprisingly, other school readiness indicators suspected to be important for academic success (child social skills, aggression and emotional distress), did not reach statistical significance. Recently, Duncan's 2007 study has been replicated with more diverse samples from Canada and the United States (Grissmer, Grimm, Aiyer, Murrah & Steele, 2010; Pagani, Fitzpatrick, Archambault & Janosz, 2010; Romano, Babchishin, Pagani & Kohen, 2010). In addition to replicating Duncan's results, researchers have also expanded these findings to show that kindergarten fine motor skills also represent key independent predictors of later achievement in elementary school (Grissmer et al, 2010; Pagani et al, 2010).

Promoting the mechanisms of learning

Because of strong empirical evidence for their involvement in later achievement, there has been a strong emphasis on increasing children's knowledge of numbers and vocabulary prior to school entry. Although this represents a worthwhile pursuit,

a focus on content knowledge without considering the mechanisms of learning is likely to miss the boat developmentally speaking (Blair 2002). When surveyed, a large proportion of kindergarten teachers in the United States reported that close to half of their students are ill-prepared to meet the challenges of the classroom. Most teachers specifically identified problems with children's ability to focus attention, sit still and follow instructions in the classroom. In contrast, fewer teachers identified children's lack of skills in math and reading as problematic (Rimm-Kaufman, Pianta & Cox 2000). Furthermore, teachers tended to report that children's ability to self-regulate behaviour, pay attention and effectively manage behaviours are among the most important student skills (Rimm-Kaufman et al 2002). Poor self-regulation on the behalf of children also contributes to growing rates of teacher burnout and may be responsible for high rates of expulsion from preschools and psychotic drug prescriptions given to very young children (Gilliam & Shahar, 2006; Hastings & Bham, 2003; Olfson, Crystal, Huang & Gerhard, 2010). In sum, how teachable young children are in the classroom may play an important role in early academic success. For this reason, neuroscientists increasingly suspect that efficient strategies should include components that foster child self-regulation and strong learning skills that enhance the acquisition of knowledge (Bierman, Domitrovich, Nix, Gest, Welsh, Greenberg, Blair, Nelson & Gill, 2008; Blair & Diamond, 2008).

Executive functions

Which skills are likely to underlie children's ability to manage their own behaviour and attention in the classroom? Research in the field of neuroscience has highlighted the importance of cognitive skills known as executive functions for helping individuals exercise control over their own behaviour. Executive function skills are mediated by the prefrontal cortex and undergo considerable development between the ages of 3 and 5 (Garon, Bryson & Smith, 2008; Marsh, Gerber & Peterson, 2008). These skills are involved in self-organisation, emotion regulation, the monitoring and changing of ongoing behaviour, the ability to plan future behaviour and the ability to develop effective strategies when faced with novel tasks and changing situations. Executive functions are central to children's ability to adapt to new situations and engage in goal-directed, deliberate or effortful behaviour. For these reasons, they are critical for child adjustment in the elementary classroom setting.

Three main components of executive functions are inhibitory control, working memory, and attention (Garon et al 2008). These skills are correlated, yet remain dissociable from one another (Miyake, Friedman, Emerson, Witzki, Howerter & Wager 2000). Inhibitory control allows children to override automatic responses in favour of more adaptive, goal-directed or effortful behaviour. Working memory helps children keep information *online* during problem solving tasks. As a result, working memory is an important contributor to children's ability to keep time, represents meaning during reading activities and holds units of information in mind while solving math problems. Finally, attention shifting and control play a role in helping children hold and refocus attention towards relevant stimuli.

Poor executive function ability in children is likely to manifest itself in a number of noticeable ways in the classroom. For example, some children may keep disorganised desks and messy lockers. Such children may also engage in more risky thrill-seeking behaviour. Children with lower levels of executive functions have a hard time sitting still, following sequential instructions and managing time. Poor executive functions are also associated with difficulties in controlling impulses to lash out when frustrated, interpersonal communication and social problem solving. Consequently, poor executive functions are often accompanied by difficulties cooperating with others and poor relations with peers (Lee, Lahey, Owens & Hinshaw, 2008).

Preschool executive functions deficits are linked to a greater risk of developing psychopathologies. Difficulty with inhibitory control is considered a central factor in childhood attention deficit hyperactivity disorder (ADHD) (Barkley 1997). Other research has provided evidence that poor frontal lobe functioning and executive functions may underlie the poor behavioural restraints observed in conduct disorder and more severe antisocial personality disorder (Moffitt, 1993; Moffitt & Henry, 1989). Finally, poor executive functions have been shown to play a role in the development of anxiety disorders (Airaksinen, Larsson & Forsell, 2005; Tucker & Derryberry, 1992).

Executive functions and school readiness

Executive functions in young children are likely to play an important role in helping children acquire the skills they need to succeed upon transitioning to formal schooling. There is a strong link between preschool executive function skills and kindergarten performance in math (Blair & Razza, 2007; Bull & Scerif, 2001; Butterworth, Varma & Laurillard, 2011; Cirino, 2010; Fitzpatrick & Pagani, 2012). Other research suggests a strong link between child executive functions and the ability to spell, compose, edit and understand written content (Altemeier, Abbott & Berninger, 2008; Altemeier, Jones, Abbott & Berninger, 2006; Blair & Razza, 2007). Finally, executive function skills are also important for helping children meet the social and interpersonal demands of kindergarten and elementary school classrooms.

Better executive functions at school entry can also favour children's classroom engagement (Fitzpatrick & Pagani, 2012; Razza, Martin & Brooks-Gunn, 2010). Classroom engagement refers to children's ability to remain on-task and successfully adapt to the demands of the classroom environment. An engaged child works autonomously, follows directions, completes tasks on time and works cooperatively with other children. Consequently, classroom engagement skills are likely to require inhibitory control, working memory and attention shifting skills. When considered as school readiness indicators, classroom engagement has been found to predict achievement and psychosocial functioning above and beyond math and reading skills (Fitzpatrick & Pagani 2013).

The development of executive functions

Executive functions develop as the prefrontal lobes mature during childhood and early adulthood (Marsh, Gerber & Peterson 2008). Even though the prefrontal

cortex develops well into the twenties, it undergoes rapid improvements during the preschool years (Shonkoff & Phillips 2000). Brain development prior to age 5 culminates in children's increased ability to exercise wilful control over behaviour and to delay gratification (Mischel, Shoda & Rodriguez 1989) and to understand the inner states of others through the acquisition of theory of mind (Sabbagh, Xu, Carlson, Moses & Lee 2006). Although genes provide the basic blueprint for brain expansion and the development of executive functions, these skills remain highly sensitive to early environments and experiences (Shonkoff & Phillips 2000).

Unfortunately, the home environments of disadvantaged children differ systematically from the environments of their more advantaged peers (Duncan, Kalil & Ziolkowski 2013). Children that grow up poor experience more family instability, stressful life events and harsh and/or inconsistent parental discipline. They are also more likely to be victims of child abuse and neglect, and are exposed to more violence in their homes (Duncan & Brooks-Gunn 1997). Finally, disadvantaged children are read to less, watch more television, attend poorer quality daycares, have lower quality diets and are exposed to more pollutants in the air they breathe and water they drink (Evans 2004). Each of these factors has been shown to have an adverse effect on brain functioning. The cumulative experience of these risk factors is therefore likely to significantly undermine neurocognitive development.

Educational and cognitive inequalities between children who grow up in poverty and their more affluent peers are evident early in life (Bradley & Corwyn, 2002; Duncan, Yeung, Brooks-Gunn & Smith, 1998). By age 2.5, disadvantaged children have smaller vocabularies, perform more poorly on tests of general cognitive ability, and have lower scores on tasks that require executive function skills (Hackman & Farah, 2009; Noble, McCandliss & Farah, 2007). These differences widen by the time children enter school, persist in the elementary school years and take their biggest toll on high school graduation rates (Duncan & Brooks-Gunn 1997).

Enhancing executive functions

Although executive functions are not typically targeted through interventions, they can be. Computerised training, classroom instruction and curriculum, aerobic exercise, mindfulness training and martial arts have all been found to have a positive effect on child executive functions (Bierman et al, 2008; Diamond, Barnett, Thomas & Munro, 2007; Flook, Smalley, Kital, Galla, Kaiser-Greenland, Locke, Ishijima, Kasari, 2010; Kamijo, Pontifex, O'Leary, Scudder, Wu, Castelli, Hillman, 2011; Klingberg, Fernell, Olesen, Johnson, Gustafsson, Dahlström, Gillbert, Forssberg & Westerberg, 2005; Klingberg, Forssberg & Westerberg, 2002; Lakes & Hoyt, 2004; Lillard & Else-Quest, 2006). It is noteworthy that physical training and martial arts, which are not traditionally thought to improve cognitive performance, were linked to the development of executive functions. This suggests that recent tendencies to reduce time devoted to physical education in schools may not be ideal for the promotion of executive functions. Furthermore, a common general finding, which emerged from the evaluation of these interventions, is that they tend to be most beneficial for children considered at higher

risk (Diamond & Lee 2011). These include children with initially lower levels of executive function ability, children from disadvantaged families, children with ADHD, as well as boys (Diamond & Lee 2011). Consequently, targeting executive functions appears especially promising for equalising inequalities in achievement between advantaged and disadvantaged children.

Conclusion

Old wisdom dictates that “a stitch in time saves nine”. Today, research confirms this old adage. Economics and the neuroscience of early brain development have shown that for every dollar invested in a high quality preschool interventions, a return of 9 dollars can be expected (Heckman 2006). From a public policy perspective, investment in preschool children therefore represents a rather lucrative investment of taxpayer dollars. Well-designed and carefully implemented preschool programmes hold the greatest potential for reducing socioeconomically-based disparities in achievement, which fuel the intergenerational transmission of poverty. In particular, targeting executive function skills, which underlie the ability to learn and exercise self-control, can benefit later professional and personal success. The successful implementation of these interventions may therefore represent our most promising strategy for reducing a number of expensive social problems including high school dropout, employment, and involvement in crime.

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