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Executive Functions in the Classroom

Clancy Blair, PhD

NYU Steinhard, USA

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Introduction

Executive functions refer to cognitive abilities involved in the control and coordination of information in the service of goal-directed actions.[1,2] As such, executive functions can be defined as a supervisory system that is important for planning, reasoning ability and the integration of thought and action.[3] At a more fine-grained level, however, executive functions, as studied in the cognitive development literature, has come to refer to specific interrelated information processing abilities that enable the resolution of conflicting information; namely, working memory, defined as the holding in mind and updating of information while performing some operation on it; inhibitory control, defined as the inhibition of prepotent or automatized responding when engaged in task completion; and mental flexibility, defined as the ability to shift attentional or cognitive set among distinct but related dimensions or aspects of a given task.[4,5,6,7]

Subject

Executive functions are of growing interest in the field of child development research as an indicator of child health and well-being generally and of self-regulation specifically. The extent to which young children can appropriately resolve conflicting information and inhibit automatic

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responding when needed is seen as an indicator of the capacity for reflection and the ability to guide behaviour using future-oriented thinking. Such abilities should, in turn, lead to well regulated behaviour and to increased adaptation to a variety of contexts. Over the past two decades, a number of studies have demonstrated the feasibility of measuring executive function in young children.[8,9,10] As well, during this time period a number of studies have demonstrated that executive functioning is meaningfully related to a number of aspects of child development including social-emotional competence[11,12] and early academic ability.[13,14,15] Studies of the development of attention deficit hyperactivity disorder (ADHD) and conduct problems, as well as research on learning disabilities,[16] indicate that executive function deficits may be a central aspect of these disorders.[17]

Problems

Several issues are relevant to research on executive functions in children. Primarily these issues relate to construct definition and validity and to the need for measures suitable for longitudinal use. Importantly, prior research with diverse test batteries with adult samples has indicated the presence of three distinct but interrelated factors for executive functions, namely, working memory, inhibitory control and attentional flexibility.[18] Similar measurement work with young children, however, it has yielded evidence of only a single underlying factor associated with executive function ability.[19,20] These findings have given rise to questions about a possible differentiation of executive functions from a single factor into distinct factors in adolescence or young adulthood. They have also led to questions about inherent limits on the measurement of executive function abilities in young children and the idea that assessments may become more precise with age. Additionally, these questions have highlighted the need for measures of executive function that can be used longitudinally with children. Most measures of executive function appropriate for use with young children tend to discriminate ability within a relatively narrow age range with ceiling and floor effects at older and younger ages.[21] Recently, however, a number of measures have been developed that are appropriate for longitudinal use.[22,23]

Key Research Questions

Given evidence indicating that executive function is important for school readiness and a central aspect of self-regulation in children, key questions relate to the identification of the relevant influences on the development of executive function and on its malleability. Of specific interest are questions relating to the ways in which poverty affects executive function development and

the idea that effects of poverty on it might account in part for socioeconomic status (SES) related gaps in school readiness and early school achievement.

Recent Research Results

Recent research results provide valuable insight into the development of executive functions in early childhood. Several measures appropriate for longitudinal use with children as young as 30 months of age have been developed and are being validated. These include a version of the Dimensional Change Card Sort (DCCS) task appropriate for longitudinal use,[24] as well as a measure known as the Shape School.[25] Similarly, an innovative task battery has been developed that contains distinct tasks designed to measure working memory, inhibitory control and attentional flexibility.

Increased precision in the definition and measurement of executive functions in children has gone hand in hand with longitudinal studies examining its development and its relation to multiple aspects of child development. Several studies, using a variety of measures, have demonstrated moderate to large associations between executive function ability and school achievement in the early elementary grades.[13,14,15,26,27] Importantly, these associations were observed when controlling for general intelligence or for early indicators of achievement, or both; in fact, executive function measures substantially attenuated or fully accounted for variance in outcomes associated with measures of general intelligence and early academic ability.

Results from a number of studies, including a population-based longitudinal sample of children followed from birth in predominantly low-income homes indicate that the quality of parenting mediates effects of the social and demographic risk on the development of executive functions at age 3.[28,29,30] As well, findings from the longitudinal study demonstrate that stress physiology, as indicated by levels of the *glucocorticoid hormone cortisol* in children, is related to executive functions and mediates in part effects of parenting and early risk on executive functions.[29]

Demonstration of relations between early experience and executive functions and between executive functions and social-emotional and academic outcomes have given rise to intervention studies examining executive functions as a potential target of efforts to promote social-emotional and academic competence in children at high risk for school failure. Results from these studies are generally positive, either suggesting or indicating that program-related changes in executive

functions mediate, to some extent, program effects on academic and behavioural outcomes.[30,31,32]

Research Gaps

Current gaps in the literature include the need for greater precision in the longitudinal measurement of executive functions in early childhood, the identification of early precursors of executive function development that can be measured in the infant and toddler period, and evidence on the malleability or trainability of executive function development. Increased precision in the longitudinal measurement of executive functions will allow for a better understanding of the typical developmental course of executive function ability and on determinants of change in executive functions. Identification of early precursors can help to provide information on early indicators which can be used to identify risk for executive function and self-regulation difficulties in early childhood. Innovative parenting or early child care programs might reasonably be expected to increase executive functioning in early childhood. A central gap in research on executive function development concerns the extent to which it is modifiable by experience.

Conclusions

Research on executive functions in early childhood has increased exponentially over the last decade. In general, the research literature on the construct indicates that executive functions can be reliably and validly measured in early childhood and that measures of executive function ability are meaningfully related to multiple aspects of child development including social-emotional and academic outcomes. As such, extant research has tended to confirm that executive function development is a central indicator of school readiness abilities. As well, research suggests that early executive function deficits may be sensitive indicators of risk for learning disability and perhaps of risk for early developing psychopathology. More research is needed, however, on the developmental course of executive function abilities, not only in early childhood but throughout middle childhood and adolescence. As well, research is needed to address relevant aspects of children’s home and school environments that may promote or impede executive function development. Increased understanding of experiential influences on executive function development can be paired with a growing research base on the underlying neurobiology of executive cognition.

Implications for Parents, Services and Policy

Evidence indicates the relevance of executive function abilities to a number of aspects of healthy child development. This evidence highlights an ongoing need for the identification of specific aspects of experience and specific pedagogical approaches that exercise executive function abilities. Evidence linking executive function abilities to school readiness and early school achievement suggest the possibility of developing new curricular approaches or modifying existing approaches in early childhood programs and in the early elementary grades to more explicitly focus on executive function abilities. Current evidence suggests that early childhood programs that focus on self-regulation may be effective in promoting executive function abilities in children.[32,33] Indeed, it may be that diverse types of activities ranging from yoga to mindfulness training to martial arts to aerobic exercise have broad benefits on core attention shifting, impulse control and working memory abilities that comprise executive functions.

References

1. Fuster, J. M. (1997). *The prefrontal cortex. Anatomy, physiology and neuropsychology of the frontal lobe*. NY: Lippincott-Raven Press.
2. Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, 24, 167-202.
3. Shallice, T., & Burgess, P. (1996). The domain of supervisory processes and temporal organization of behaviour. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 351(1346), 1405-1411.
4. Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4-13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, 44, 2037-2078.
5. Diamond, A. (2002). Normal development of prefrontal cortex from birth to young adulthood: Cognitive functions, anatomy, and biochemistry. In D. Stuss & R. Knight (Eds.), *Principles of frontal lobe function* (pp. 466 – 503). New York: Oxford.
6. Garon, N., Bryson, S.E., & Smith, I.M. (2008). Executive function in preschoolers: a review using an integrative framework. *Psychological Bulletin*, 134, 31–60.
7. Zelazo, P. D., & Müeller, U. (2002). Executive function in typical and atypical development. In U. Goswami (Ed.), *Blackwell Handbook of Childhood Cognitive Development* (pp. 445–469). Oxford, UK: Blackwell Publishers.
8. Diamond, A., & Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to ‘‘do as I say, not as I do.’’ *Developmental Psychobiology*, 29, 315 – 334.
9. Espy, K. A. (1997). The shape school: Assessing executive function in preschool children. *Developmental Neuropsychology* , 13(4), 495-499.
10. Zelazo, P.D. & Reznick, J.S. (1991). Age related asynchrony of knowledge and action. *Child Development*, 62, 719-735.
11. Carlson, S.M., Mandell, D.J., & Williams, L. (2004). Executive function and theory of mind: stability and prediction from age 2 to 3. *Developmental Psychology*, 40, 1105–1122.
12. Hughes, C. & Ensor, R. (2007). Executive function and theory of mind: Predictive relations from ages 2- to 4-years. *Developmental Psychology*, 43, 1447-1459.

13. Blair, C. & Razza, R. P (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, 78, 647-663.

14. Bull, R., & Scerif, G. (2001). Executive functioning as a predictor of children's mathematics ability: Inhibition, switching, and working memory. *Developmental Neuropsychology*, 19(3), 273-293.

15. Espy, K. A., McDiarmid, M. M., Cwik, M. F., Stalets, M. M., Hamby, A., & Senn, T. E. (2004). The contribution of executive functions to emergent mathematic skills in preschool children. *Developmental Neuropsychology*, 26(1), 465-486.

16. Geary, D. C., Hoard, M., Byrd-Craven, J., Nugent, L. & Numtee, C (2007). Cognitive mechanisms underlying achievement deficits in children with mathematical learning disability. *Child Development*, 78, 1343-1359.

17. Arnsten, A. F., & Li, B. M. (2005). Neurobiology of executive functions: Catecholamine influences on prefrontal cortical functions. *Biological Psychiatry*, 57(11), 1377-1384.

18. Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, 41(1), 49-100.

19. Wiebe, S. A., Espy, K. A., &Charak, D. (2008). Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. *Developmental Psychology*, 44, 575-587.

20. Willoughby, M. T., Blair, C. B., Wirth, R. J., Greenberg, M., & the Family Life Project Investigators (2010). The measurement of executive function at age 3 years: Psychometric properties and criterion validity of a new battery of tasks. *Psychological Assessment*, 22, 306–317.

21. Carlson, S. A. (2005). Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology*, 28(2), 595-616.

22. Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4-13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, 44, 2037-2078.

23. Willoughby, M. T., Wirth, R. J., & Blair, C. B. (2011). Contributions of modern measurement theory to measuring executive function in early childhood: An empirical demonstration. *Journal of Experimental Child Psychology*, 108, 414-435.

24. Zelazo, P. D. (2006). The dimensional change card sort (DCCS): A method of assessing executive function in children. *Nature Protocols*, 1(1), 297-301.

25. Espy, K.A., Bull, R.B., Martin, J. & Stroup, W. (2006). Measuring the development of executive control with the Shape School. *Psychological Assessment*, 18, 373-381.

26. McClelland, M. M., Cameron, C. E.., Connor, C. M., Farris, C. L., Jewkes, A., M., & Morrison, F. J. (2007). Links between behavioral regulation and preschoolers' literacy, vocaculary and math skills. *Developmental Psychology*, 43, 947-959.

27. Welsh, J. A., Nix, R. L., Blair, C., Bierman, K. L., & Nelson, K. E. (2010). The development of cognitive skills and gains in academic school readiness for children from low-income families. *Journal of Educational Psychology*, 102(1), 43-53.

28. Bernier, A., Carlson, S.M., & Whipple, N. (2010). From external regulation to self-regulation: early parenting precursors of young children's executive functioning. *Child Development*, 81, 326–339.

29. Blair, C., Granger, D. Willoughby, M., Mills-Koonce, R., Cox, M., Greenberg, M.T., Kivlighan, K., Fortunato, C. & the FLP Investigators (2011). Salivary cortisol mediates effects of poverty and parenting on executive functions in early childhood. *Child Development*, 82, 1970-1984.

30. Hammond, S. I., Müller, U., Carpendale, J. I. M., Bibok, M. B., & Liebermann-Finestone, D. P. (2011). The effects of parental scaffolding on preschoolers' executive function. *Developmental Psychology*. Advance online publication. doi: 10.1037/a002551.

31. Bierman, K.B., Nix, R.L., Greenberg, M.T., Domitrovich, C., & Blair, C. (2008). Executive functions and school readiness intervention: Impact, moderation, and mediation in the Head Start – REDI program. *Development and Psychopathology*, 20, 821-843.

32. Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science* 318(5855), 1387-1388.

33. Raver, C. C., Jones, S. M., Li-Grining, C. P., Zhai, F., Bub, K., & Pressler, E. (2011). CSRP's impact on low-income preschoolers' pre-academic skills: Self-regulation as a mediating mechanism. *Child Development.*82, 362-378.