



There is evidence that creating challenge can have a positive impact on children's executive function but only limited evidence suggesting impacts on self-regulation outcomes. 'Creating and navigating challenge' means educators creating developmentally appropriate challenges for children to develop their skills and giving them opportunities to practice and repeat them in different contexts. Educators responsively scaffold and adapt the level of support they provide as children navigate through challenges. They may explicitly pose problems, make suggestions, or use increasingly complex instructions to increase challenge. Educators also model ways to adjust the level of challenge or remind children there are strategies they can implement. This enables the level of challenge to be adapted, rather than removed. Educators create a supportive environment for children to navigate challenges in different contexts throughout the day. This technical summary covers two broad types of intervention that involve creating and navigating challenge: cognitively engaging physical activities and cognitive training.

One way of creating challenge is through physical activity that involves complex movements and adapting to changing task demands, such as taking part in basketball, martial arts, or street dancing. Two systematic reviews evaluated the impact of creating challenges in this way (Li et al., 2020; Muir et al., 2023); both suggested that these cognitively engaging physical activities are associated with improved executive function outcomes such as working memory,¹ inhibitory control,² and cognitive flexibility³—perhaps to a greater extent than physical activities that do not have cognitive challenge (Li et al., 2020). Barnett et al. (2008) and one study each from Bond (2022) and Jacob and Parkinson (2015) that were not included in the two reviews provide some additional support for providing challenge through physical activity. However, in those studies physical activity was only one component of a much broader programme. The cognitively engaging physical activity discussed here is distinct from general physical activity (such as running or jumping) that is not as cognitively demanding. General physical activity is covered under the approach of 'Promoting Physical Activity'.

Research has also investigated the impact of creating challenges through cognitive training programmes and games. In these interventions, children typically engage with structured games designed to improve one or more executive functions, moving through 'levels' in which material gets progressively more challenging. There is some evidence that using computerised cognitive training programmes improves

executive function outcomes. For example, in the 'Fruit Ninja' game used to develop inhibitory control, children click on all the fruit on the screen while simultaneously ignoring any bombs that appear (Liu et al., 2015). Three systematic reviews (Jacob and Parkinson, 2015; Muir et al., 2023; Scionti, 2020), along with one primary study (Zhang et al., 2019), suggested that children who engage with these kinds of training tasks often improve performance on the games themselves or on specific measures of executive function (though the majority of studies do not measure self-regulation). However, effects of computerised cognitive training do not always extend to broader educational outcomes (Jacob and Parkinson, 2015; Muir et al., 2023; Scionti, 2020). Cognitively challenging games are another form of cognitive training (for example, in the game 'I went to the market and I bought ...', children repeat the list they have just heard and add one item to the shopping list). The limited evidence base for these non-computerised training tasks and games is mixed, with Muir et al. (2023) finding limited effectiveness and another review finding computerised and non-computerised training to be equally effective (Scionti et al., 2020). However, Muir et al. (2023) did find that mediated structured play⁴—where educators initiate play-based activities that increase in their cognitive complexity—has the potential to improve executive function outcomes for children in the early years.

We found some limited evidence that creating challenge may be differentially effective for at-risk children. A meta-analysis of cognitive training interventions concluded that effects were stronger for children from lower-income families than those from higher-income families (Scionti et al., 2020). Creating challenge, especially via cognitive training exercises, may therefore be particularly effective for certain subgroups of children. Research suggests certain conditions may support effective adoption of this approach. Incrementally increasing challenge based on the child's performance may be more effective than guiding children through preset levels of complexity (Muir et al., 2023). Cognitive training may be especially effective when an educator provides metacognitive scaffolding for the child while they are completing the training tasks (for example, by providing suggestions or asking questions such as, 'I wonder what would happen if...'; Pozuelos et al., 2019).⁵ Some evidence also suggests that cognitive training is more likely to lead to positive outcomes when implemented with a group rather than individually (Scionti et al., 2020). However, care should be taken when introducing cognitive challenge through classroom games. Game-based approaches can help children to enjoy and

¹ Working memory is an executive function that describes our ability to temporarily hold and manipulate information in our mind. It acts like a mental notepad that helps us complete tasks and solve problems.

² Inhibitory control is an executive function and describes our ability to control our urges and to think before we react.

³ Cognitive flexibility is an executive function that characterises our capacity to switch between different tasks and cognitive processes. It involves the ability to shift attention and modify thinking in response to changing situational demands.

⁴ The review's authors define 'mediated structured play' as a guided and intentional form of play where an adult provides children with play-based activities that have a specific objective, in contrast to free or unstructured play where children play without direction or guidance from an adult.

⁵ Metacognition refers to the ways learners monitor and purposefully direct their learning.



engage, though it can be difficult to suitably tailor the level of challenge to individual children when playing as a group (Muir et al., 2023; Scionti et al., 2020).

Common practices featured in our evidence base for this approach included enabling repetition and providing opportunities to practise. In most of the interventions, games comprise structured activities that increase in difficulty and complexity. For example, children could dance to music and freeze once the music stops, with complexity of the challenge increased by changing the game's rules. Providing children with opportunities to test out different strategies was also common. There were also interventions where the educator provided prompts or suggestions to help children when they struggled with challenges. However, in many of the studies, the role of the educator was not described. For cognitive training programmes

in particular, children appeared to complete activities independently by using technology with minimal supervision; this may be less applicable to very young children.

The majority of the studies underpinning this approach involved research with four- to six-year-olds, with a smaller number involving children aged three. Studies were only included if the majority of children were aged six or under. The evidence base comes from a range of countries, including the United States, the United Kingdom, Australia, China, and Spain. Studies often tested interventions delivered by highly trained researchers or through computer programmes with limited adult input. It is therefore important to consider that findings from these studies may not generalise well to real early years settings (Muir et al., 2023).



References

Included evidence reviews

Bond, N. (2022) 'The Effectiveness of Self-Regulation Interventions for Increasing Cognitive and Social-Emotional Functioning of Preschool-Aged Children: A Systematic Review', Master's thesis, University of Canterbury, Christchurch. <http://dx.doi.org/10.26021/12662>

Jacob, R. and Parkinson, J. (2015) 'The Potential for School-Based Interventions that Target Executive Function to Improve Academic Achievement: A Review', *Review of Educational Research*, 85 (4), pp. 512–552. <https://doi.org/10.3102/0034654314561338>

Li, L., Zhang, J., Cao, M., Hu, W., Zhou, T., Huang, T., Chen, P. and Quan, M. (2020) 'The Effects of Chronic Physical Activity Interventions on Executive Functions in Children Aged 3–7 Years: A Meta-Analysis', *Science and Medicine and Sport*, pp. 949–954. <https://doi.org/10.1016/j.jsams.2020.03.007>

Muir, R., Howard, S. and Kervin, L. (2023) 'Interventions and Approaches Targeting Early Self-Regulation and Executive Functioning in Preschools: A Systematic Review', *Educational Psychology Review*, 35 (27). <https://doi.org/10.1007/s10648-023-09740-6>

Scionti, N., Cavallero, M., Zogmaister, C. and Marzocchi, G. M. (2020) 'Is Cognitive Training Effective for Improving Executive Functions in Preschoolers? A Systematic Review and Meta-Analysis', *Systematic Review*, 10 (2812) <https://doi.org/10.3389/fpsyg.2019.02812>

Scionti, N., Cavallero, M., Zogmaister, C. and Marzocchi, G.M. (2020) Corrigendum: Is Cognitive Training Effective for Improving Executive Functions in Preschoolers? A Systematic Review and Meta-Analysis. *Front. Psychol.* 11:410. <https://doi.org/10.3389/fpsyg.2020.00410>

Included primary studies

Barnett, W. S., Kwanghee, J., Yarosz, D. J., Thomas, J., Hornbeck, A., Stechuk, R. and Burns, S. (2008) 'Educational Effects of the Tools of the Mind Curriculum: A Randomized Trial', *Early Childhood Research Quarterly*, 23, pp. 299–313. <https://doi.org/10.1016/j.ecresq.2008.03.001>

Liu, Q., Zhu, X., Ziegler, A. and Shi, J. (2015) 'The Effects of Inhibitory Control Training for Preschoolers on Reasoning Ability and Neural Activity', *Nature Scientific Reports*, 5 (14200). <https://doi.org/10.1038/srep14200>

Pozuelos, J. P., Combata, L. M., Abundis, A., Paz-Alonso, P., Conjero, A., Guerra, S. and Rueda, M. R. (2018) 'Metacognitive Scaffolding Boosts Cognitive and Neural Benefits Following Executive Attention Training in Children', *Developmental Science*, 22 (e12756). <https://doi.org/10.1111/desc.12756>

Rueda, M. R., Checa, P. and Cómbita, L. M. (2012) 'Enhanced Efficiency of the Executive Attention Network After Training in Preschool Children: Immediate Changes and Effects After Two Months', *Developmental Cognitive Neuroscience*, 25, S192–S204. <https://doi.org/10.1016/j.dcn.2011.09.004>

Schmitt, A., McClelland, M. M., Tominey, S. L. and Acock, A. C. (2015) 'Strengthening School Readiness for Head Start Children: Evaluation of a Self-Regulation Intervention', *Early Childhood Research Quarterly*, 30, pp. 20–31. <http://dx.doi.org/10.1016/j.ecresq.2014.08.001>

Zhang, Q., Wang, C., Zhao, Q., Yang, L., Buschkuehl, M. and Jaeggi, S. M. (2019) 'The Malleability of Executive Function in Early Childhood: Effects of Schooling and Targeted Training', *Developmental Science*, 22 (e12748). <https://doi.org/10.1111/desc.12748>