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Demystifying Executive Function

Abstract

Executive function (EF) is an umbrella term for a set of complex and nuanced cognitive processes believed to be uniquely human. EF allows for planning, adaptation and self-regulation to meet personal or imposed goals. It develops from early childhood and is recognised as a key predictor of academic outcome and life chances. Related difficulties affect many people across the lifespan, yet current UK government education guidance focuses on early years. Information freely available to parents and educators tends to present a deficit model that offers an understanding of potential difficulties without providing practicable cohort-level or individual support strategies. This article aims to contextualise current understandings of EF. It outlines the gradual development and factors that can impact development as well as conditions commonly co-occurring with EF delay or dysfunction. Strategies are presented that the author tested as part of master's research conducted in school and reported on elsewhere. Techniques for scaffolding and direct instruction in metacognitive strategies can be adapted, for many teaching and learning scenarios, to support development of academic skills and greater independence for learning. Supportive strategies are discussed in the context of universal design for learning, an inclusive framework for planning and teaching, that classroom practitioners, specialist teachers and others working in education might consider for their future practice.

Introduction and background

The functions of the brain's prefrontal cortex have been documented and discussed since the 1840s and the case of Phineas Gage, injured when a small crowbar passed through the front of his skull (see MacMillan, 2008). Yet, educators have only in recent years become more aware of the term executive function (EF) to describe a conceptualisation of brain functions and development. At the same time, in the UK, the terminology has crept into government guidance. For example, Ofsted (2023) notes that early years educators should consider how best to develop children's EF. Indeed, executive function–with self-regulation–is the sixth of seven key features of *effective teaching and learning* in the Department for Education's (DfE, 2023) curriculum guidance for the Early Years Foundation Stage (EYFS). Arguably, the EF-targeted recommendations from Ofsted noted above simply repackage guidance for good early years practice provided two decades ago without reference to brain function.

Sometimes referred to as EF dysfunction, EF difficulties are recognised as co-occurring or significant features of learning differences. Beyond early years, EF is perhaps most likely to be discussed by teachers working with students diagnosed with or considered to have special educational needs, or by the parents of those same children and young people. Parent awareness of EF has risen in recent years; an Internet search conducted in July 2016 found limited data related to parent's knowledge of EF (Gillie, 2016). By contrast, in February 2024, a Facebook search using the term 'executive function UK' returned results including many general groups alongside others aimed at intersectional

demographics and individuals with discrete diagnoses alongside offers of related services. For example, a closed group titled ‘Executive Function Support for Parents’ created in 2023 had gained over 8000 members since its creation a year before.[1]

Difficulties and delays with executive functioning are often associated with neurodivergent cognitive profiles, including autistic spectrum; attention deficit/hyperactivity disorder; developmental coordination disorder/dyspraxia and dyslexia (Capodieci et al., 2023). To understand the possible impact of EF support needs in the context of schools, it can be useful to consider that 40% of England’s 2016 GCSE cohort were recorded on schools’ special educational needs registers at some point between Reception (7%) and Year 11 (14%) (Hutchinson, 2017). It is important to note that this figure is not cumulative, and some children may have spent just one year receiving SEN support. For a similar cohort of home university students–those enrolled at English higher education institutions in the 2019-20 academic year–the proportion was 17.3% (Hubble & Bolton, 2021). This included all students with a known disability, encompassing ‘special’ education, specific learning differences and neurodivergence as well as mental health needs and/or physical disability. Given a widely accepted prevalence rate for neurodivergence of 15-20%, related barriers to learning will affect individuals in most, if not all, educational environments (Doyle, 2020).

[1] https://www.facebook.com/groups/2282338581944007

Models of executive function

Models of EF propose up to 33 aspects and 5 categories of EF.[2] However, simpler conceptualisations seem to offer a way to usefully consider what are complex brain processes. This might foster a common understanding of EF, arguably essential if educators are to collaborate and implement strategies to support learners (Gillie, 2017). Zelazo and Müller (2010) suggest a 'hot' affective strand and a 'cool' effective strand: difficulties in skills important for learning can provoke an emotional response and/or emotions might impact on learning. This model has parallels with the behavioural and cognitive components presented and assessed by Gioia et al. (2000). Both are visualised in figure 1.

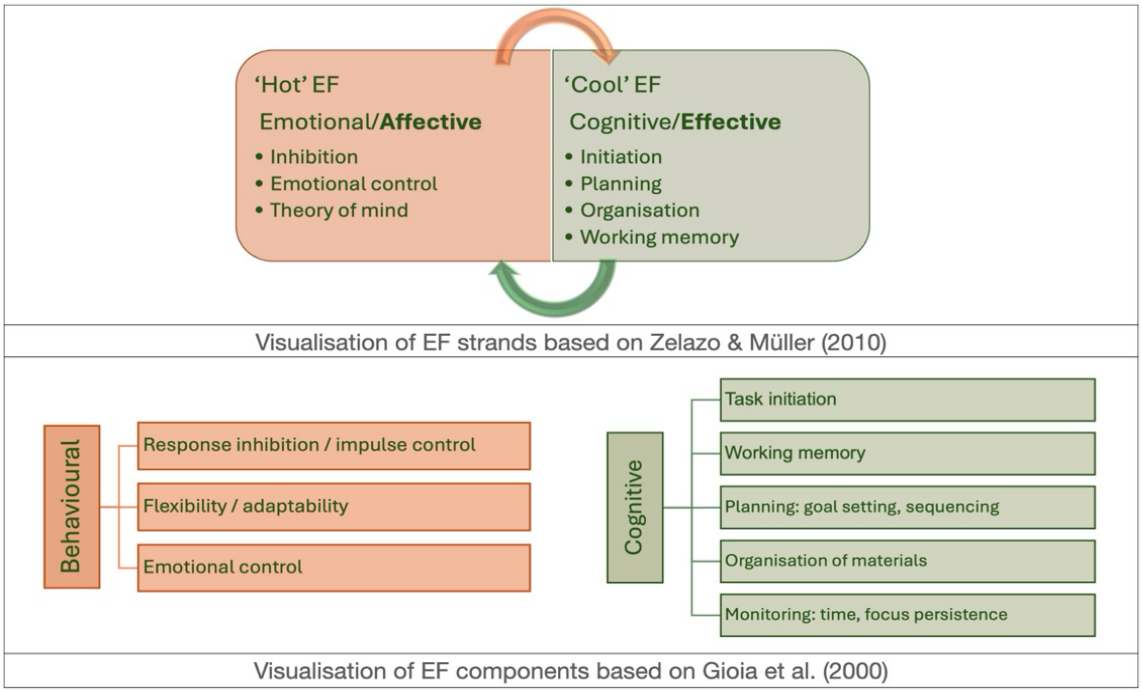

Figure 1 Models of EF

[2] See, for example https://learninguniversally.wordpress.com/2019/04/26/simplifying-executive-function/

Working memory, the ability to hold information in mind and transform it, is often included in, or conflated with models of EF. Theory of mind, the capacity to recognise and consider the perspectives of others, is also found in some models of EF. Research has found EF development can affect when and how children begin to understand possible differences between perspectives, key in theory of mind (Carlson et al., 2015). Moreover, Bradford et al. (2015) suggest that the effort to understand different perspectives can put significant strain on a person's ability to draw on EF-related skills.

Understanding executive function

That the frontal lobes of the brain affect aspects of human behaviour has been acknowledged for close to two centuries. Barkley (2012) suggests that the human capacity for vicarious learning is a result of the evolutionary expansion of the prefrontal cortex accompanying the development of both EF and theory of mind, itself an aspect of EF (Zelazo & Müller, 2010). In recent years, educators have become more aware of certain areas of the brain and their functions, for example the 1970s conceptualisation of a 'central executive' and working memory (Baddeley & Hitch, 2000). Perhaps the word 'executive' has led to a conflation in public perceptions of EF, working memory and the functions of this part of the brain, which Zelazo and Müller (2010) contend is an unhelpful oversimplification. This is reflected in the findings of Gilmore and Cragg (2014) that difficulties in learning related to EF are more often ascribed to working memory by classroom teachers.

Discrepancies in the conceptualisations of EF may lead to apparently contradictory findings in research exploring its impacts on learning (Jacob & Parkinson, 2015). Furthermore, quantitative EF research has tended to employ psychological tests in 1:1 conditions, which Kaufmann (2010) contends cannot reflect the experiences and performance of students in busy learning environments. The challenge is not limited to psychometric tests and extends to the assessment of a learner's EF based on educator or parent report. Meltzer et al. (2018) consider that students' difficulties with planning, organisation and other EF skills underpinning 'successful' schoolwork may cloud educators' and parental views of a child's or young person's academic potential. Their preferred assessment of EF would combine observations in home and school settings as well as carefully selected cognitive assessments, interview and ratings from parents and educators as well as self-reports (Meltzer et al., 2018).

Executive function and learning

It can be argued that the prominence of EF in current early years guidance puts unrealistic expectations on young children and early years practitioners alike. Perhaps this is because guidance seems to imply standard and controllable development of brain function linked to cognitive and behavioural skills. Diamond (2006) outlines the development of working memory, inhibition and cognitive flexibility over time, starting in early years and continuing across and beyond children's primary school years. As for other aspects of human development, children and young people attain maturity in various aspects of EF at different rates, while still at school and into adulthood, some of this linked to growth spurts (Jurado & Roselli, 2007). A range of factors including

environment (Holmes Bernstein & Waber, 2018), exercise (Ziereis & Jansen, 2015), socioeconomic status (Bierman & Torres, 2016) and trauma (Cohodes et al., 2020) are recognised as affecting development or application of EF aspects.

Throughout EF development, educators, peers, employers and family members may act as external EF, the more knowledgeable other in Vygotsky's Zone of Proximal Development (1978). Moran and Gardner (2018) outline EF development through children's secondary schooling and into adulthood. They contend that whereas the expectation is that all young people will develop EF skills for independent living, for some adults, life and work routines fulfil this role. Barkley's (2012) detailed work to map aspects of EF development in children and young adults with specific learning differences has at times been grossly overgeneralised, including in viral social media posts. For example, a graphic circulated since 2017 erroneously states that children and adults with ADHD are 30% behind their typically developing peers across all aspects of EF development.[3] Such misinformation aimed at educators and parents can result in lower ambitions on behalf of neurodivergent children and young adults and risks their educational disenfranchisement.

Moreover, there is plenty that can be done to support the development of skills that place demands on EF. Avoiding deficit models disseminated online and understanding core aspects of EF can enable educators to work with students and develop skills to tackle tasks with high EF demand. Figure 2 offers a visualisation of functions and behaviours linked to EF and illustrates the

[3] https://ar.pinterest.com/pin/executive-functioning--123356477289574061/

potential positive and/or negative impact of environmental factors. The model places concepts from Barkley's (2012) discussion of differences and delays linked to EF within Frith's (1999) interactive factors framework and extends the environmental factors for support in the context of universal design for learning.

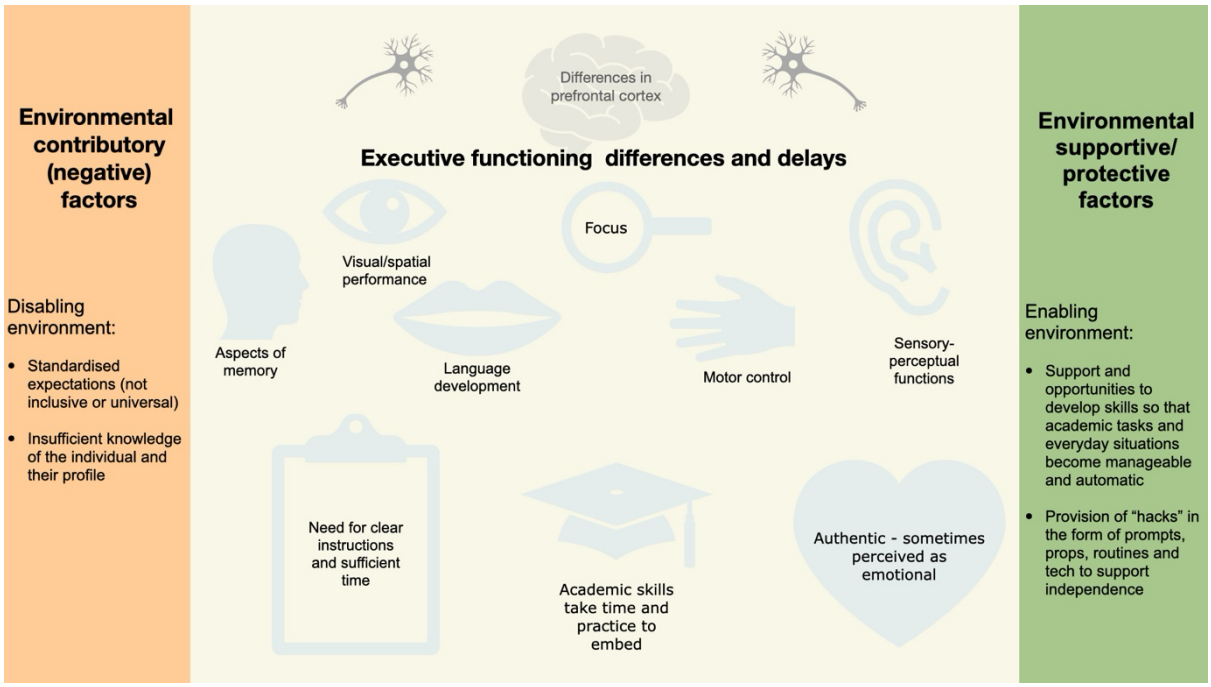

Figure 2 Interactive factors framework for EF based on Barkley (2012)

EF 'interventions'

As noted, it is possible teachers do not understand the scope and impact of EF difficulties on day-to-day classroom learning due to confusion or conflation with working memory (Zelazo & Müller, 2010). Working memory can be assessed with ease psychometrically in schools and research laboratories, settings where quantitative results have primacy. This may have compounded the extent to which working memory is seen as a proxy for EF. In the early 2000s, much was made of the potential for computerised programmes to improve working memory. These continue to be marketed to schools as a way of improving

attention and working memory, particularly for children with diagnosed or suspected learning differences, for example, Pearson's Cogmed Working Memory Training.[4] However, successive reviews have indicated that the duration of benefits from such training, and its generalisability into everyday learning situations are far from clear (see, e.g. Pergher et al., 2020). Moreover, individual educators may not have access to computerised interventions.

Inclusive practices such as universal design for learning (UDL) can be employed at cohort level to benefit all learners, and reasonable adjustments can be put in place for particular groups and individuals where needed (see, e.g. Quirke et al., 2023). The UDL[5] framework is intended to remove barriers to learning through clarifying **what** is to be learned - recognition and/or representation; **how** it can be learned - the skills and strategies and/or action and expression; and **why** it should be learned - caring and prioritising and/or engagement.

Everyday academic tasks require well-developed EF. For example, to write a short sentence, the writer must employ complex fine motor control and:

- know what they want to say and how they want to say it (planning, goal setting, sequencing),
- remember and spell each word in the correct order (working memory),

[4] https://www.pearsonclinical.co.uk/store/ukassessments/en/Store/Professional-Assessments/Cognition-%26-Neuro/Memory/Cogmed-Working-Memory-Training-/p/P100009002.html

[5] Information and resources for UDL can be accessed at: https://www.cast.org/impact/universal-design-for-learning-udl

- keep track of all of this (monitoring: time, focus, persistence).

For more on EF and writing, see Dockrell et al. (2016) and for EF and maths, see Gilmore and Cragg (2014).

An approach that can work well for both literacy and numeracy is to use visualisation and verbalisation, proposed by Bell (2007). For reading and writing, visualisation allows interpretation of spoken and written language that supports the development of comprehension skills. Verbalisation, talking about ideas, supports both comprehension and more fluent writing. Both visualising and verbalising can provide 'hacks' when working memory is under pressure, and to aid with organisation. For maths, verbalisation can demystify the language of mathematical operations and aid with interpretation and sequencing of word problems. With these elements supported, focus may be maintained more easily. To work towards visualisation, start with manipulatives, first making the abstract concrete. This can be begun in early years with any objects, gradually progressing through resources such as Numicon, MathLink cubes, Cuisenaire rods, etc., into secondary education. Discussed by Vygotsky (1978), self-talk is another form of verbalisation, talking through the steps to complete a task, as a reminder for maths calculations or spelling as well as for more complex processes. This can be introduced at cohort level to destigmatise the strategy. Over time, repeated talking through of a process can support its internalisation and the development of automaticity, reducing the strain on EF aspects including working memory and sequencing.

In formal education and work, EF difficulties might manifest in a person's ability to process and follow instructions: remembering each element (working memory); getting started (initiation); doing the right thing at the right time (planning and sequencing) and with the right equipment (organisation); staying on task and completing (focus, persistence). How each EF component might impact on a given task is not always predictable and may change depending on a wide variety of factors including the room configuration, tiredness, external stimuli, etc. A quick fix for educators (and employers) could be to habitually 'chunk' verbal information to provide clear guidance on **what** to do and **how** to do it. As for the visualisation and verbalisation already discussed, this technique sits well in a UDL paradigm.

In many instances, a handout, poster or online resource will help. From a digital perspective, the range of free and inexpensive apps designed to aid organisation and note-taking is growing all the time and these can act as external EF while also supporting independence. Educators can make templates, prompts and guides available in their organisation's virtual learning environment. I do this for my own students in Teams: students access their individual copy–which I can make editable–and they can share with me for formative feedback if appropriate. Whilst time and effort are required to develop initial practices and materials, once in place, these are adaptable and reusable in the longer run. In terms of visual displays, it should not be assumed that a poster on its own is enough, some time will need to be invested in ensuring that everyone knows how to use such prompts. Where used, online guides should

be available accessible formats, video or audio with transcript, text with audio or text-to-speech enabled.

From early years to higher education and employment, strategies should be made explicit, so that everyone knows what the skill is for. A metacognitive UDL approach can be powerful as it enables understanding of the point of the technique, its methods and benefits, **what** to do and **why** to do it. Adopting this across teaching spaces, subjects, tasks and over time will help individuals to generalise and embed the skills necessary for academic and professional success. This reflects Bruner's (1976) spiral curriculum, which recognises that mastery, depth and complexity is built on foundational abilities and concepts, and that any idea or skill might first be explored practically (Kivunja, 2015).

Where some children may seem to develop skills for study naturally or through a kind of academic osmosis, the same is not true of all learners, whether they have specific learning differences or not. Clear instruction in study skills should benefit all students. Examples might include explicit training in planning written work and use of tools such as mind-maps and flashcards. Arguably, this might permit some learners to gain greater independence, and allow busy educators extra time with those who need more individualised attention.

Closing thoughts

Although awareness of EF has increased in recent years, there continues to be some conflation with working memory. Online memes and government focus on self-regulation risk a deficit model of EF rather than exploring inclusive practices that can support children and adults. Implementing universal design for learning

through all stages of education and training simply reflects the inclusive practice expected in enabling learning environments.

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