

Think twice before you...

At the forefront of research on Executive Functions, **Professor Adele Diamond** describes how we can improve our inhibitory control, working memory and cognitive flexibility to help us think before we act.

RESEARCH FOCUS

Professor Diamond's lab studies developmental science, cognitive science and neuroscience, incorporating behavioural, cognitive, and molecular genetic methods to study prefrontal cortex and executive functions - complex cognitive abilities. Executive functions include a number of crucial skills for everyday life. Cognitive flexibility is the ability to see things from different perspectives and 'think outside the box'. Working memory allows us to mentally relate facts and ideas to one another. Inhibitory control helps us not act impulsively, think before acting, resist temptations and stay focused. These skills are invaluable for reasoning, problem solving and creativity. They are key for success in life.

Diamond's Developmental Cognitive Neuroscience lab examines how the prefrontal cortex and executive functions are influenced by biological factors, such as genes and neurochemistry, and by environmental factors, including detrimental influences like poverty and stress and facilitative ones such as interventions. For example, the lab is investigating how the unusual properties of the dopamine system in prefrontal cortex contribute to the exceptional sensitivity and vulnerability of prefrontal cortex and executive functions to environmental and genetic variations that have little effect elsewhere in the brain.

Another research aim is finding practical ways of helping children to develop healthy executive functions so they will thrive in life. Diamond's team proposes a rather different perspective from mainstream education: they hypothesise that focusing exclusively on cognitive skills is less efficient, and ultimately less successful, than also addressing youths' emotional, social and physical needs. They theorise that alongside cognitive skill training, it is important to support those skills by enhancing things that support them (such as social support) and reducing things that impair them (such as stress).

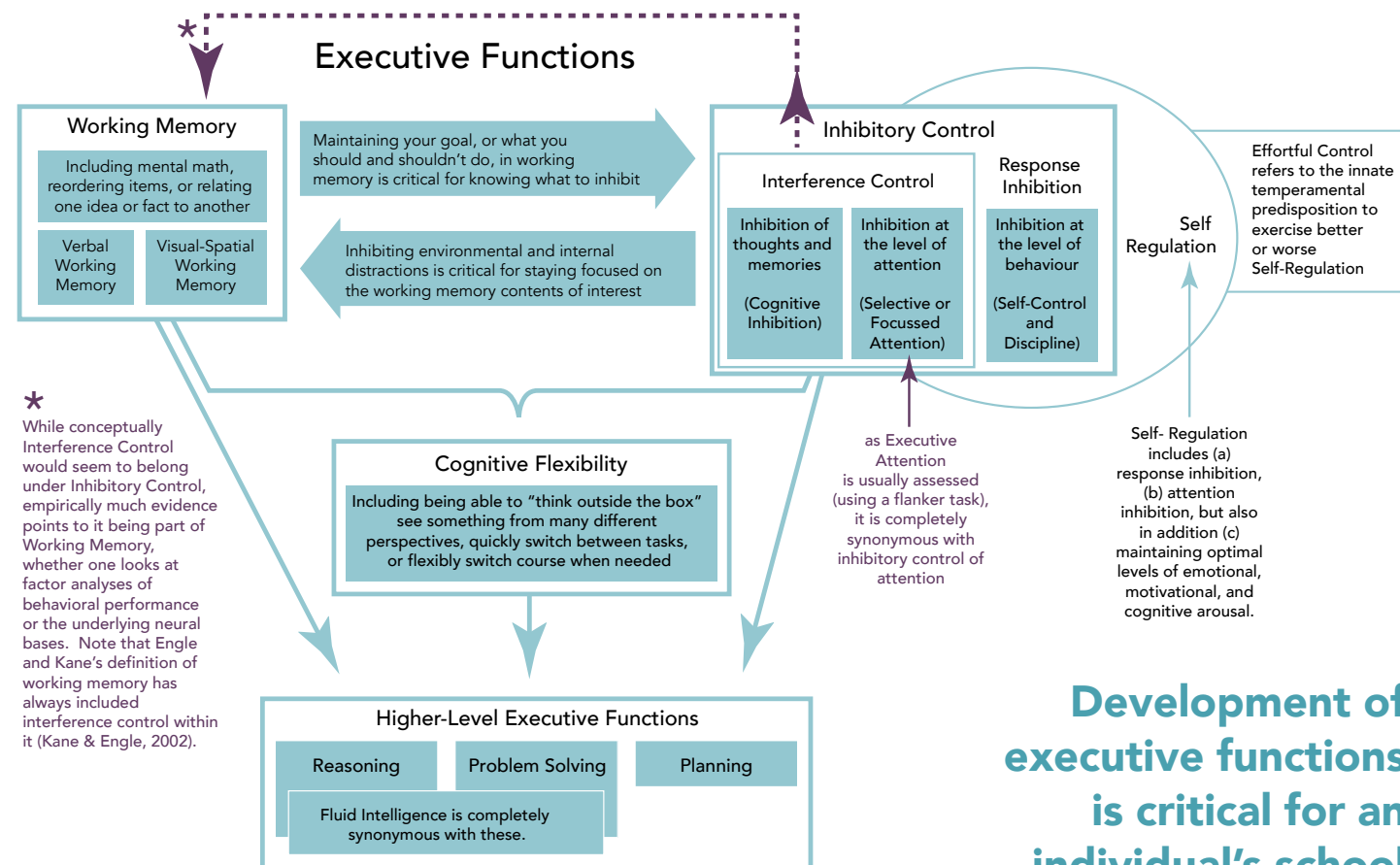
Diamond hopes that her team's research will help fundamentally change the approach and underlying assumptions of how to improve cognitive skills and how to educate children. They aim to develop evidence that focusing exclusively on training cognition might not be the best way to improve cognition and that emotional and social factors are crucial to cognitive improvement. Activities such as sports, play, dance and music-making make us happy and proud and give us a sense of belonging. These cultural activities and others, such as mindful practice, like yoga or martial arts, require focus, concentration and working memory, challenge our executive functions and build us as people.

At the University of British Columbia in Vancouver, world leading neuroscientist, Professor Adele Diamond, is collaborating with trainee, Daphne S. Ling, to produce what will be a ground-breaking broad review of current research on interventions and programs to improve executive functions. Diamond describes executive functions as developable skills that consist of working memory, inhibitory control and cognitive flexibility. Executive functions enable us to reason, problem-solve, think before we act, see things from new and different

perspectives, and to flexibly adapt to changing demands or priorities. Without these higher cognitive processes we would be at the mercy of our impulses, unable to resist temptations or stay focused on important tasks. Having good executive functions enables individuals to thrive socially, professionally and economically - within the complexity of our modern world.

Researchers in the field are developing various techniques for improving executive functions, such as cognitive training or physical exercise. Diamond and Ling describe their work as the first review to

Executive Functions



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comprehensively evaluate all the different methodologies of experimental executive function training and to look across all age groups. Identifying 8 fundamental principles that appear to apply to all methods of training of executive functions, Diamond and Ling's review provides a vital appraisal of the evidence gathered so far, with some surprising results.

NAVIGATING THE MINEFIELDS OF EVERYDAY LIFE

Various researchers have shown that the development of executive functions appears to be critical for an individual's school readiness, as well as their future academic and career success. We also need these cognitive skills for maintaining positive friendships, marital harmony and good health. While executive functions are positively enhanced by socioeconomic security, well-being and good health, executive functions are negatively impaired by life or economic stresses, traumas, poor health and loneliness. Diamond underlines the importance of executive functions for navigating the minefields of everyday life, and that executive functions "are sometimes more predictive than IQ

or socioeconomic status" for future life successes.

The good news is that neuroscientists think that executive functions can be improved at any age. We can all reap the benefit of boosting our cognitive functions for observable real world benefits. Diamond and Ling analyse a broad range of studies to evaluate the evidence for the actual cognitive benefits of different types of activities, such as physical exercise and computerised training. They call on future researchers "to follow principles of good design that have so often been violated in training studies." Diamond and Ling's review invaluable outlines correct practice for experimental executive function training.

CHARTING NEW TERRITORIES: WHAT WORKS?

Diamond and Ling identify weaknesses within approaches for testing the effectiveness of experimental executive function training. The researchers point out that the placebo effect of taking part in a research study is sometimes not fully considered by researchers, an oversight that may lead to an erroneous conclusion

that an intervention was effective. Thus, it is critically important to compare the training to another new program that participants also have high hopes for. Also, researchers need to show that a program both produces more improvement in executive functions than the control condition and results in better executive functions than the control condition. Studies of the benefits of physical activity for executive functions, in particular, have been plagued by differences in executive functions at the outset. Too often the control group starts out better and the training group simply catches up so that the groups do not differ on executive functions after the training. When that happens one cannot know whether normally developmental processes, regression to mean, or the

training caused the experimental group to catch up to the controls.

Diamond and Ling conclude that the evidence shows that CogMed®, a computer-based training approach, is the most effective way thus far of improving working memory. Additionally school programs, such as MindUP™, PATHS®, Tools of the Mind®, and the Chicago School Readiness Project, provide the 'best results for improving inhibitory control' thus far in children in preschool through Grade 4. The researchers also indicate that Taekwondo, Integrative Body-Mind Training, yoga and theatre have demonstrated favourable outcomes for improving executive functions, but there is only one intervention study of each so far.

Conversely, Diamond and Ling suggest that the 'weight of the evidence' indicates that Mindfulness-Based Stress Reduction (MBSR), a program developed by Jon Kabat-Zinn in the 1970s involving meditation and body awareness, and N-back tasks, or task switching, do not improve executive functions (Note, though, that MBSR's benefit for EFs with stressed individuals has yet to be studied.) Diamond and Ling conclude that the least effective form of physical activity for improving executive functions is 'mindless' aerobics or resistance training, which does not engage higher cognitive faculties. However, promising benefits are offered by physical activities that are both physically and cognitively challenging, such as Taekwondo and Yoga.

SUCCESS AND SOCIAL EQUALITY

Diamond's research suggests that executive function training will be most beneficial for persons with: lower working memory spans, worse attention, ADHD, and adults at the beginnings of cognitive decline. These

groups demonstrate larger observable improvement after training than others. A positive equalising effect is particularly clear in socioeconomically disadvantaged children. Children from lower socioeconomic backgrounds are often behind their more advantaged peers in the development of executive functions. These disadvantaged children exhibit the most improvement from targeting executive functions.

Diamond and Ling believe that effective EF training can help to 'reduce social disparities in academic achievement', as well as in health, but the implications of their review are even more far-reaching. As a lack of impulse control is associated with criminal activity, boosting low executive functioning could proactively ward someone off from committing criminal acts or from re-offending. Similarly, improving an individual's executive functions can lead to a corresponding improvement in their professional, economic and social success. Considering the societal benefits offered by improving the population's cognitive performance, Diamond and Ling's systematic evaluation of various approaches to executive function training paves the way to innovatively combat societal inequality. Early intervention appears to be key.

• Adele Diamond and Daphne S. Ling's upcoming 'Review of the evidence on, and Fundamental Questions surrounding, Efforts to improve Executive Functions (including working memory)' will soon be published in the book, 'An Integrative Approach to Cognitive and Working Memory Training: Perspectives from Psychology, Neuroscience, and Human Development' (Oxford University Press)

Detail

RESEARCH OBJECTIVES

Prof. Diamond is at the forefront of research on 'executive functions' and on the brain's prefrontal cortex on which they depend. Executive functions include 'thinking outside the box' (cognitive flexibility), mentally relating ideas and facts (working memory), and giving considered responses rather than impulsive ones, resisting temptations and staying focused (inhibitory control, including selective attention).

AFFILIATIONS

- Fellow of the Royal Society of Canada since 2009
- Founding Fellow of the Institute of Mental Health, University of British Columbia
- Charter Member and Fellow of the Association for Psychological Science
- Fellow of the American Psychological Association (in 3 separate divisions)

BIO

Professor Adele Diamond is the Canada Research Chair (Tier 1) Professor of Developmental Cognitive Neuroscience at the University of British Columbia in Vancouver. She is a member of the Royal Society of Canada and was recently recognized as one the 15 most influential neuroscientists in the world today.

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