

## How Does Medication Effect Executive Functions?

*This supplemental handout provides an overview of available information about how medication may impact executive functioning.*

When considering the effects of medication for ADHD on executive functions (EFs), it is important to understand how EF is defined and how it is measured. (See pdf entitled *What Are Executive Functions and How Are They Related to ADHD?*). EFs can be measured by neuropsychological tests, such as tests of sustained attention, response time, planning, and flexibility (also called set-shifting). They can also be measured by parent and teacher versions of several available EF rating scales (see Abikoff & Gallagher, 2009; Gioia, et al., 2000; Meltzer, et al, 2018). Unfortunately, tests do not necessarily correlate well with a child's daily EF functioning, whereas rating scales may be influenced by the rater's point of view about other aspects of the child's behavior. Given the limits of measurement, somewhat consistent findings include the following:

- Most studies show that medication-related improvement in EFs are related to improvement in core ADHD symptoms.
- Some of the tests that are most often used to measure EFs, such as continuous performance tests, also measure core ADHD symptoms, such as sustained attention and impulsivity.
  - Some researchers consider sustained attention, or attention regulation, as EFs while they are **also** core ADHD symptoms. Similar overlap exists between the EF behavioral inhibition and the core symptom of impulsivity. This measurement overlap may be one of the reasons that EF and core symptom improvement are related.
- Improvement in EF is most likely to be shown in children with more severe EF dysfunction and more severe ADHD symptoms (Hale, et al., 2011)
- When rating scales have been used in studies of medication effects on EF, they are most often parent-completed versions.
  - In this situation, we cannot know how much the parent's rating reflects what they interpret from what teachers report to them, versus their own observations of the child outside of school, when medication is less likely to be in effect.
- Most studies of medication effects on EF use methylphenidate.
  - There are many fewer studies of amphetamines, atomoxetine, viloxazine, and guanfacine. Overall, studies suggest small to moderate improvement, though results with guanfacine are uncertain at this time (reviewed in Faraone, et al., 2021a)
- While methylphenidate, amphetamine, atomoxetine and viloxazine all have some evidence for improving EF while in use, there is limited evidence of any persistence of effects (Faraone, et al., 2021b)
- The most consistent improvements are reported in sustained attention and behavioral inhibition, with some studies reporting improvement in working memory, and few reporting improvement in cognitive flexibility (Cortese, et al., 2018; Semrud-Clikeman, et al., 2008; Swanson et al., 2011; Tamminga, et al., 2016).
- In many studies, one executive function (example: working memory) may be measured in by more than one test, and improvements may be seen on one test but not the other. If the

treated group improves overall more than the placebo group, the medication is considered to have improved that EF, even though specific characteristics of the test may influence the results (Blum, et al., 2011; see Swanson, et al., 2011, for a review of tests). Similarly, there may be improvement on one rating of EFs but not another (Faraone, et al., 2023)

- Improvement in EFs may occur at lower doses of stimulant medication than behavioral improvement based on an ADHD rating scale, so some EF improvement may be “missed” when optimal doses are determined by behavior improvement on an ADHD rating scale (Hale, et al., 2011).
- Other types of cognitive processes that are neither EFs nor core ADHD symptoms that are impacted by ADHD (reviewed in Swanson, et al., 2011) may improve on medication, such as spatial planning (Ni, et al, 2013), visual-spatial working memory (de Jong, et al., 2009), non-executive memory, reaction time, reaction time variability (Coghill, et al., 2014), and color naming speed (Tannock, et al., 2000).
- Even when there is improvement, more than half of students still have difficulty with organization, time management, and planning skills, so treatments targeting EF skills, as described in the presentations, are still important (Abikoff, et al., 2009; Torun, et al., 2020)
- As with ADHD, the combination of medication and psychosocial treatments typically offers the best chance of improvement, and in some studies, medication improved the outcomes of psychosocial treatment (reviewed in Storer, et al., 2014).

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