What Are Executive Functions?

Completing most tasks requires the successful orchestration of several types of executive function skills. Among scientists who study these functions, three dimensions are frequently highlighted: **Working Memory**, **Inhibitory Control**, and **Cognitive or Mental Flexibility**.[1,2,3] In most real-life situations, these three functions are not entirely distinct, but, rather, they work together to produce competent executive functioning.

WORKING MEMORY is the capacity to hold and manipulate information in our heads over short periods of time. It provides a mental surface on which we can place important information so that it is ready to use in the course of our everyday lives. It enables us to remember a phone number long enough to dial it, to return to our place in a magazine article before a friend interrupted us, and to recall whether we had added the salt to what we were cooking before we had to help our child find a missing shoe. It enables children to remember and connect information from one paragraph to the next, to perform an arithmetic problem with several steps, to keep track of the moves and make a logical next step in a game of checkers, and to follow multiple-step instructions without reminders ("go to your cubbies, put away your storybooks, bring back your arithmetic books, and open them to page 30"). It also helps children with social interactions, such as planning and acting out a skit, taking turns in group activities, or easily rejoining a game after stepping away to get a drink of water.

INHIBITORY CONTROL is the skill we use to master and filter our thoughts and impulses so we can resist temptations, distractions, and habits and to pause and think before we act. It makes possible selective, focused, and sustained attention, prioritization, and action. This capacity keeps us from acting as completely impulsive creatures who do whatever comes into our minds. It is the skill we call on to push aside daydreams about what we would rather be doing so we can focus on important tasks. It is the skill we rely on to help us "bite our tongue" and say something nice, and to control our emotions at the same time, even when we are angry, rushed, or frustrated. Children rely on this skill to wait until they are called on when they know the answer, to be good at games like "Simon Says" and "Red Light/Green Light," to stop themselves from yelling at or hitting a child who has inadvertently bumped into them, and to ignore distractions and stay on task in school.

COGNITIVE OR MENTAL FLEXIBILITY is the capacity to nimbly switch gears and adjust to changed demands, priorities, or perspectives. It is what enables us to apply different rules in different settings. We might say one thing to a co-worker privately, but something quite different in the public context of a staff meeting. If a friend asks if we like her new haircut and we don't, we are able to flexibly shift to the social convention that governs not hurting people's feelings. Likewise, we teach our children about "outside voices" and "inside voices" and the different situations in which they should use each. As the author of *The Executive Brain,* Elkhonon Goldberg, notes, "The ability to stay on track is an asset, but being 'dead in the track' is not."[4] Stated differently, self-control and persistence are assets, rigidity is not. Cognitive flexibility enables us to catch mistakes and fix them, to revise ways of doing things in light of new information, to consider something from a fresh perspective, and to "think outside the box." If the "church in two blocks" where we were told to turn right is actually a school, we adjust and turn anyway. If we are missing a recipe ingredient, we call a neighbor or make a substitution. Children deploy this skill to learn exceptions to rules of grammar, to approach a science experiment in different ways until they get it to work, or to try different strategies when they are working out a conflict with another child.

Building the Foundations of an "Air Traffic Control" System in the Brain

Executive function skills do not just appear in adulthood. They are built over time, starting as early as the first year of life, with more complex skills building on the simpler skills that came before. Executive function skills are also highly interrelated. Just as an air traffic control system requires the interaction of multiple people—pilots, navigators, controllers, weather forecasters—our human executive functioning system requires that each type of skill utilize elements of the others. For example, it takes working memory to hold two rules in mind and inhibitory control to ignore one of the rules in order to flexibly switch between rules as they change. This table presents examples of how these interrelated executive function skills develop when children have the proper scaffolding by adult caregivers.

WORKING MEMORY	INHIBITORY CONTROL	COGNITIVE FLEXIBILITY
ADULT Can remember multiple tasks, rules, and strategies that may vary by situation	**ADULT** Consistent self-control; situationally appropriate responses (e.g., resists saying something socially inappropriate, resists "tit for tat" response)	**ADULT** Able to revise actions and plans in response to changing circumstances
5-16 YEARS Develops ability to search varying locations, remember where something was found, then explore other locations (e.g., a game of Concentration or hiding a penny under one of three cups)	**10-18 YEARS** Continues to develop self-control, such as flexibly switching between a central focus (such as riding a bike or driving) and peripheral stimuli that may or may not need attention (road signs and pedestrians vs. billboards and passing houses)	**13-18 YEARS** Continued improvement in accuracy when switching focus and adapting to changing rules
4-5 YEARS Comprehends that appearance does not always equal reality (e.g., when given a sponge that looks like a rock)	**7 YEARS** Children perform at adult levels on learning to ignore irrelevant, peripheral stimuli (such as a dot on the side of a screen) and focus on the central stimulus (such as a picture in the middle of the screen)	**10-12 YEARS** Successfully adapts to changing rules, even along multiple dimensions (okay to shout on playground, not okay in school, okay sometimes in theater rehearsal)
3 YEARS Can hold in mind two rules (e.g., red goes here, blue goes there) and act on the basis of the rules	**4-5 YEARS** Reductions in perseveration (persisting with following a rule even when knowing that the rule has changed). Can delay eating a treat; also can begin to hold an arbitrary rule in mind and follow it to produce a response that differs from their natural instinct (sort colored cards by shape rather than color)	**2-5 YEARS** Succeeds at shifting actions according to changing rules (e.g., takes shoes off at home, leaves on at school, puts on boots for rain)
9-10 MONTHS Can execute simple means-to-ends tasks and two-step plans; also able to integrate looking one place and acting (e.g., reaching) at another place	**9-11 MONTHS** Able to inhibit reaching straight for a visible but inaccessible reward, such as a toy on the other side of a window, and instead delay a moment to recognize the barrier and detour around it	**9-11 MONTHS** Develops ability to seek alternate methods to retrieve objects beyond directly reaching for what's in view
7-9 MONTHS Develops ability to remember that unseen objects are still there (toy hidden under a cloth); learns to put two actions together in a sequence (remove cloth, grasp toy)	**8-10 MONTHS** Begins to maintain focus despite distractions during brief delays in a task	
	6 MONTHS Rudimentary response inhibition (able to not touch something instructed not to touch)	

Sources: Best & Miller (2010)[100]; Diamond (1991a, 1991b, 2002, 2006).[101,102,8,103]