Factors that Aid and Factors that Hinder the Development of Executive Functions

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What abilities and skills will children need to be successful in the 21st century?
1) Self-control
to resist temptations and not act impulsively

• wait your turn, raise your hand, don’t try to grab a toy from another child
• think before you speak or act so you don’t do something you’d regret or put your foot in your mouth
• wait before making up your mind; not jumping to a conclusion or an interpretation of what something must have meant or why it was done
• resist blurting out what first comes to mind
• not give in to the heat of the moment (wait before pressing ‘send’ to an angry email)
• resist ‘tit for tat’ (hurting someone because that person hurt you)
2) Discipline & Perseverance

Having the discipline to stay on task and complete it

resisting temptations to quit because

- frustrated by setbacks, lack of progress
- bored because too easy
- more fun things are calling

continuing to work even though the reward may be a long time in coming

(delivering gratification)
Evidence shows that discipline accounts for over twice as much variation in final grades as does IQ, even in college.

(Duckworth & Seligman, 2005)
3) Attentional Control

• Being able to concentrate,
• Pay attention, &
• Stay focused

even when the material is boring
Young children have very immature attentional control. They can easily get distracted by beautiful posters on the wall.
Minimize Extraneous Distraction

Anna Fisher et al. (2014)
Visual Environment, Attention Allocation, and Learning in Young Children: When Too Much of a Good Thing May Be Bad

*Psychological Science*
vol 25, p. 1362-1370
While it may make the room look beautiful to put up lovely posters on the walls, young children are able to pay better attention, and learn more, when the walls are more bare, though each wall can be painted a beautiful color.
4) Creativity in seeing connections between seemingly unconnected ideas or facts.

Playing with information and ideas in your mind, relating one to another, then disassembling those combinations and recombining the elements in new ways.

Working memory involves holding information in mind and working with it.
5) Creativity in seeing familiar things in new ways / from different perspectives

If one way of solving a problem isn’t working, can we conceive of the problem in a different way?

Can we think outside the box to come up with a different way of attacking the problem?
If you always do what you always did, you’ll always get what you always got.

- Einstein
Karen Pape, MD: “Habit Hides Recovery”

By thinking outside the box, Dr. Pape has been able to help children with motor coordination problems when everyone else had given up:

www.devcogneuro.com/videos/Karen_Pape_composite_10min.mp4

longer version: www.devcogneuro.com/videos/Karen_Pape_composite_42min_52sec.mp4
6) Flexibility

Having the flexibility….

• …to take advantage of unexpected opportunities / serendipity

• …to navigate around unforeseen obstacles, and

• …to admit you were wrong
An example of poor cognitive flexibility:

When one door closes, another door opens; but we often look so long and so regretfully upon the closed door, that we do not see the ones which open for us.

- Alexander Graham Bell
“Executive Functions” is shorthand for all of the abilities I just mentioned.
Executive Functions are needed whenever going ‘on automatic’ would be insufficient or detrimental.
The 3 core Executive Functions are:

- **Inhibitory Control** (which includes self-control, discipline, and attentional control)
- **Working Memory** (holding info in mind & MANIPULATING it; essential for reasoning)
- **Cognitive Flexibility** (including creative problem-solving & flexibility)

Higher-order Executive Functions are:

- Problem-solving
- Reasoning
- Planning
Children with better inhibitory control (i.e., children who were more persistent, less impulsive, and had better attention regulation) later as teenagers, are LESS likely to

- make risky choices,
- have unplanned pregnancies, or
- drop out of school

and
as adults 30 years later have...

- better health
- higher incomes and better jobs
- fewer run-ins with the law
- a better quality of life (happier)

than those with worse inhibitory control as young children,
controlling for IQ, gender, social class, & home lives & family circumstances growing up across diverse measures of self control.
That’s based on a study of 1,000 children born in the same city in the same year followed for 32 years with a 96% retention rate.

by Terrie Moffitt et al. (2011)

“Interventions that achieve even small improvements in [inhibitory control] for individuals could shift the entire distribution of outcomes in a salutary direction and yield large improvements in health, wealth, and crime rate for a nation.”

Terrie Moffitt et al. (2011)
*Proceedings of the Nat’l Academy of Sci.*
The 3 core Executive Functions are:

- **Inhibitory Control** (which includes self-control & discipline, also selective attention)
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- **Cognitive Flexibility** (including creative problem-solving & flexibility)

Higher-order Executive Functions are:

- Problem-solving
- Reasoning
- Planning
Working memory is critical for making sense of anything that unfolds over time, for that always requires holding in mind what happened earlier & relating that to what is happening now.
• relating one idea to another
• mental math calculations
• understanding cause and effect
• remembering multi-step instructions & executing them in the correct order – remembering sequences
Holding information in mind while working on something else

e.g., holding a question or comment in mind as you listen to what is currently being said
The 3 core Executive Functions are:

• **Inhibitory Control**  
  (which includes self-control & discipline, also selective attention)

• **Working Memory**  
  (holding info in mind & MANIPULATING it; essential for reasoning)

• **Cognitive Flexibility**  
  (including creative problem-solving & flexibility)

Higher-order Executive Functions are:

• Problem-solving
• Reasoning  
  • Planning
For example, try to think of as many uses for a TABLE as you can.

What are all the things you might use a table for?
You could dance on top of a table.

Might turned it on its side and use it to keep a door closed or as a shield against anything being thrown at you.

You could get under it to hide or to keep dry.

You could cut it up for firewood.
How can we stop ourselves from getting really upset when a child misbehaves? What we usually get upset about is the intent we think is behind an action.

Could use Cognitive Flexibility to re-frame:

A child might be acting in the most awful manner because he has been terribly hurt and is afraid of being hurt again, so he will push you away before you have a chance to reject him or he will test you to see if you are really someone he can feel safe with.

If we see the misbehavior as coming from hurt, we can react completely differently.
Dimensional Change Card Sort

(Zelazo, Frye, & Rapus, 1996)

Target Cards

Holding two rules in mind, and inhibiting the tendency to continue sorting by the first dimension
When sorting by COLOR, Correct Response is the Blue Star.

Card to be sorted:

Model Cards:
When sorting by SHAPE, the correct response is the Red Truck. Card to be sorted:

Model Cards:
3-year-olds sort the cards perfectly by either color or shape
but, very few 3-yr-olds can switch how they sort
See VIDEO of child starting with sorting by Shape at:

www.devcogneuro.com/videos/cardsort.mpg
See VIDEO of child starting with sorting by Color at:

www.devcoigneuro.com/videos/cardsort_faileds_witch.wmv
It is not enough to know something and remember it; you must get that knowledge into your behavior.
People have assumed that if children knew what they should do, they would do it. (If they did not, they were intentionally misbehaving.)

But, between knowing and implementing, another step, long ignored, is often needed. When there’s a strong competing response, that response must be inhibited. Young children may not be able to do that.
A child may know what he or she should do, and want to do that, but still not be able to act accordingly.
Executive Functions are important for every aspect of life – success in school and in the workplace, making & keeping friends, marital harmony, and avoiding things like unplanned pregnancy, substance abuse, or driving fatalities.

In other words, self-control, creativity, reasoning, mental flexibility, discipline and perseverance are really important – they are often more predictive than IQ.
Executive functions predict academic performance in the earliest elementary grades thru university better than does IQ. 

(Alloway & Alloway, 2010; Bull & Scerif, 2001; Dumontheil & Klingberg, 2012; Gathercole et al., 2004; McClelland & Cameron, 2011; Nicholson, 2007; Passolunghi et al., 2007; St Clair-Thompson & Gathercole, 2006; Savage et al., 2006; Swanson, 2014).
Poor EFs can also lead to poor physical health including obesity, over-eating, poor food choices, substance abuse, & poor sustained adherence to doctors’ orders (Crescioni et al. 2011; McAuley 2011; Riggs et al. 2010).

In a large sample of >14,000, Miller et al. (2011) found that youths with poorer self-control were “exponentially more likely” to suffer from 9 of the 10 adverse health conditions they examined.
Of 500 fraternal twin pairs, the twin with poorer EFs at age 5 was more likely to smoke, do poorly in school, and engage in aggressive or antisocial behavior at age 12, though each pair grew up together.

Wong et al. (2010) in *Epigenetics*
If we want children to do well in school & in life, we need to help them develop healthy exec. functions.
The good news is that Executive Functions can be improved.
Indeed, evidence shows that

- early deficits in EFs often do not disappear but can grow larger
- EFs *can* be improved in young children
- *not* preventing problems of EFs leads to poor academic performance & failing to graduate, mental health disorders, and social problems ranging from crime to unemployment
- preventing problems by getting children started on a healthy trajectory with good EFs is **more effective** and **far less costly** than trying to correct or ameliorate problems once they’ve developed
EF skills can be improved even in children as young as 4-5 years without drugs or expensive, highly technical equipment by regular teachers in regular classrooms.
Executive Functions depend on Prefrontal Cortex and the other neural regions with which it is interconnected.
Human Brain Development

Even at 20 years of age, Prefrontal Cortex is not fully mature.
Many had doubted whether EFs could be improved as early as preschool since EFs depends on PFC, and PFC isn’t fully mature until young adulthood.

In response: Analogy with a 2-year-old’s legs and walking and even running at age 2.)
Just because PFC isn’t fully functional, doesn’t mean that it isn’t functional at all.

We used to think that PFC was silent during infancy, but we now know babies can problem-solve & reason before they can speak.
There are 3 basic ways to improve functioning that requires EFs:

(a) work on EFs - train them, challenge them, & practice, practice, practice

(b) work on reducing things that impair EFs (stress, lack of sleep, etc.)

(c) find ways of reducing the demands on EFs (circumvent the need for EFs, in part) scaffolding
Vygotsky: Engaging in social pretend play is critical for developing executive function skills in very young children. It is emphasized in *Tools of the Mind*.

Children must **plan** who they want to be in a pretend scenario, and the teacher holds them accountable for
• During social pretend play, children must hold their own role and those of others in mind (working memory)

• inhibit acting out of character (employ inhibitory control), and

• flexibly adjust to twists and turns in the evolving plot (cognitive flexibility)

-- all three of the core executive functions thus get exercise.
Contrary to influential reviews of the benefits of aerobic exercise….

*Nature Reviews Neuroscience* (January 2008)

“Be Smart, Exercise Your Heart: Exercise Effects on Brain and Cognition”
Charles Hillman, Kirk Erickson & Art Kramer

In particular, the frontal lobe and the executive functions that depend on it show the largest benefit from improved fitness.

The positive effects of aerobic physical activity on cognition and brain function are evident at the molecular, cellular, systems, and behavioral level.
Exercise without a cognitive component (e.g., riding a stationary bike) probably does not improve executive functions.
Of the studies in children that had pre- and post-tests, had a control group, were not solely correlational, and looked at the effects of more than a single session on EFs from aerobic exercise, 80% found NO BENEFIT to EFs.
Of the 7 studies that have examined EF benefits from aerobic activity versus an active control group, 6 were with older adults....

2/3 of those 6 found no EF benefit whatsoever from aerobic exercise
Similarly, two meta-analyses of randomized control trials found minimal or no EF benefits from aerobic exercise.

Angevaren et al. (2008)
11 intervention studies in older adults w/out cognitive impairment

Smith et al. (2010)
17 intervention studies in adults [10 of those in adults 55 or older]
Effect of aerobic exercise on executive function (n = 19)

Executive Function

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<th>Statistics for each study</th>
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Effect of aerobic exercise on working memory (n = 12)

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Consistent with the disappointing effects of ‘mindless’ aerobics on EFs is the consistent finding that improvements in aerobic fitness are uncorrelated with cognitive improvements.

meta-analysis: Etnier et al. 2006;
review: Kramer & Erickson, 2007
People improve on the skills they practice & that transfers to other contexts where those same skills are needed -- but people *only* improve on what they practice – improvement does not transfer to other skills.
If improvement in a particular EF skill is your goal, then you need to engage in activities that require & train that EF skill.
But…
People who are more physically active and have better aerobic fitness have better EFs.

as true for kids: Scudder et al., 2014
Hillman, Castelli, & Buck 2005

as for the older adults: Boucard et al., 2012
Voelcker-Rehage, Godde, & Staudinger, 2010
Perhaps people need to do aerobic activity for longer (perhaps years versus months) or more times per week than in intervention studies.

Maybe many people who maintain better fitness do so by participating in physical activities that involve cognitive challenges.

Maybe a difference is that many people who exercise regularly do it as a mindfulness exercise, whereas it is very unlikely that first time exercisers would be doing that.

Exercise improves mood (relieves stress and depressed mood) and improves sleep. Perhaps these indirect effects of exercise when it is done for an extended time produce the cognitive benefits.

Maybe people who freely choose to do aerobic activities enjoy them more than people who are randomly assigned to them.
There’s also evidence that any benefit of physical activity for cognition may be proportional to how much joy the physical activity brings.

(Hill et al., 2010; Raichlen, Foster, Gerdeman, Seillier, & Giuffrida, 2012; Heyman et al., 2012; Wolf et al., 2010)

Boring exercise is particularly unlikely to yield cognitive benefits.
Could be that the correlation between better physical and cognitive fitness is due to one or more other variables and not to better fitness per se.

Perhaps people who are more physically fit have the good sense to eat better or get more sleep, tend to be healthier in general or tend to be more highly educated.

Or, maybe causality goes in the opposite direction since one probably needs good EFs, especially good inhibitory control and discipline, to maintain a regular exercise regimen.

At least the evidence so far seems to indicate that it is not the aerobic fitness itself that is causing the cognitive benefit.
Exercise alone appears not to be as effective in improving EFs as exercise-plus-character-development (traditional martial arts) or exercise-plus-mindfulness (yoga).
Lakes & Hoyt (2004) randomly assigned children in grades K thru 5 (roughly 5-11 years-old) by homeroom class to Taekwondo martial arts (N = 105) or standard physical education (N = 102).
Children assigned to Tae-Kwon-Do showed greater gains than children in standard phys. ed. on all dimensions of EFs studied (e.g., cognitive [focused vs. distractible] and affective [persevere vs. quit] and emotion regulation). This generalized to multiple contexts and was found on multiple measures.
Traditional martial arts emphasize self-control, discipline (inhibitory control), and character development.
In a study with adolescent juvenile delinquents (Trulson, 1986), one group was assigned to traditional Tae-Kwon-Do (emphasizing qualities such as respect, humility, perseverance, honor as well as physical conditioning). Another group was assigned to modern martial arts (martial arts as a only competitive sport).
Those in traditional Tae-Kwon-Do showed less aggression and anxiety and improved in social ability and self-esteem.

Those in modern martial arts showed more juvenile delinquency and aggressiveness, and decreased self-esteem and social ability.
Whether EF gains are seen depends on the way an activity is done.
Regardless of the program to improve EFs, a few principles hold, for example:
1. EF training appears to transfer, but the transfer is not wide. For ex., computerized working memory training improves working memory but not self-control, creativity, or flexibility.
Commercial computerized training programs are claiming widespread cognitive benefits but beware: wide transfer does not occur (on the rare occasions where it has been found, those findings have not been replicated).
To see widespread benefits, diverse skills must be practiced. Because of that, real world activities such as martial arts & certain school curricula (that train diverse executive-function abilities) have shown more widespread cognitive benefits than targeted computerized training.
Sometimes the reason something works is different from what anyone expected:

CogMed® is the most heavily researched computerized training method for improving working memory.

Although most studies of CogMed® do not mention the mentoring component,
to be certified to administer CogMed®, adults must get trained in, & commit to, mentoring those doing CogMed®.

de Jong has found that the mentoring seems to account for the benefits of CogMed® more than what’s on the computer.

de Jong, P. (May 20, 2014). *Effects of training working memory in adolescents with a below average IQ*. Presented at ‘Workshop on Enhancing Executive Functions in Education’ in Nijmegen, NL.
2. EFs need to be continually challenged to see improvements - not just used, but challenged.
Consistent with: what Ericsson reports is key for being truly excellent at anything…

Practice, practice, practice (10,000 hours) always trying to master what is just beyond your current level of competence and comfort (working in what Vygotsky would call the ‘zone of proximal development’).

The Importance of Repeated Practice

Whether EF gains are seen depends on the amount of time spent practicing, working on these skills, pushing oneself to improve.
Prefrontal cortex (what I specialize in) is over-rated.

To learn something new, we need prefrontal cortex.

But after something is no longer new, persons who perform best often recruit prefrontal cortex least.
The DLPFC Slice for 8 Individuals
The DLPFC Slice for 8 Individuals
The DLPFC Slice for 8 Individuals
The DLPFC Slice for 8 Individuals
The DLPFC Slice for 8 Individuals
When something is new, those who recruit PFC most, usually perform best.

(Duncan & Owen 2000, Poldrack et al. 2005)

But when you are really good at it, you are NOT using PFC as much.

Want to be able to use PFC whenever you...
.. are presented with the unexpected,
.. need to think outside the box,
.. need to concentrate particularly hard,
.. need to adapt to change...

BUT
Want most tasks to be so familiar and well learned that PFC is NOT needed.
Want those tasks to be handed off to subcortical regions that have had 100,000s of more years of evolutionary time to perfect their functioning and can subserve task performance ever so much more efficiently than can PFC.

(re: Zen and the Art of Archery)
A child may know intellectually (at the level of PFC) that he should not hit another, but in the heat of the moment if that knowledge has not become automatic (passed on from PFC to older brain regions) the child will hit another (though if asked, he knows he shouldn’t do that).
knowing what one should do vs.
2nd nature (automatic)
(i.e., NOT dependent on PFC)
The only way something becomes automatic (becomes passed off from PFC) is through action, repeated action. Nothing else will do.
“We are what we repeatedly do. Excellence, then, is not an act, but a habit.

We don’t act rightly because we have virtue or excellence, but we rather have these because we have acted rightly; these virtues are formed in a person by doing the actions; we are what we repeatedly do.”

Aristotle, *Ethica Nicomachea*, 4th century BC
The Importance of
...Action for Learning
...Learn through Doing
at any age, but especially for young children
a Chinese proverb:

I hear, and I forget.

I see, and I remember.

I do, and I understand.

If information is not relevant for action, we don’t pay attention in the same way (hence the difference in route memory for the driver, versus the passenger, of a car).
Hands-on Learning

We evolved to be able to learn to help us act, to help us do what we needed to do. If information is not relevant for action, we don’t pay attention in the same way (hence the difference in route memory for the driver, versus the passenger, of a car).

You learn something when you NEED it for something you want to DO.
(My son teaching me to program the VCR)

The same is true when we teach children in school. They need opportunities to concretely apply what they are taught.
When you have hands-on learning, when children are able to work on their own or in pairs or small groups then teachers can then give each child individual attention:

to observe, to listen, & to teach

(provide individual instruction)

And each child can progress at his or her own pace.
PFC is the newest area of the brain and the most vulnerable.
If you’re

• sad or stressed
• lonely
• sleep-deprived, or
• not physically fit

PFC & EFs are the first to suffer, & suffer THE MOST.
Similarly, stress, sadness, or lack of social or emotional support, often lie at the root of health problems. Asthma is a particularly clear case of this (Chen et al., 2006; Cohen, 1996; Lind et al., 2014).
Conversely, we show better EFs when we’re

• happy

• feel socially supported, &

• we’re healthy & physically fit
Indeed, it seems that what makes for the best EFs:

- less stress
- social engagement & support
- being physically active

also makes for the healthiest lives and greatest longevity

Our brains work better when we are not in a stressed emotional state.

Amy Arnsten, 1998
The biology of being frazzled
Science

This is particularly true for PFC & EFs.
Stress impairs Executive Functions and can cause anyone to look as if he or she has an EF impairment (like ADHD) when that’s not the case.

(You may have noticed that when you are stressed you cannot think as clearly or exercise as good self-control.)
Stress and Prefrontal Cortex

Even mild stress increases DA release in PFC but not elsewhere in the brain

(Roth et al., 1988)
In humans (& primates in general) there are more glucocorticoid receptors in PFC than in the hippocampus (the reverse of what’s true in rodents).

In college students, one month of stress in preparation for a major exam disrupts prefrontal cortex functional connectivity. Stress decreases coupling between left DL-PFC and right DL-PFC, and between DL-PFC and premotor cortex, the ACC, the insula, posterior parietal cortex (PPC), and the cerebellum.

Liston et al. (2009) *PNAS*
When we are sad we’re worse at filtering out irrelevant information (i.e., worse at selective attention).

Desseilles et al., 2009
von Hecker & Meiser, 2005

When we are happy we are better at selective attention.

Gable & Harmon-Jones, 2008
People show more creativity when they are happy

THE most heavily researched predictor of creativity in social psychology is mood. The most robust finding is that a happy mood leads to greater creativity (Ashby et al. 1999). It enables people to work more flexibly (Murray et al. 1990) & to see potential relatedness among unusual & atypical members of categories (Isen et al. 1985, 1987).

Hirt et al. 2008: 214
It’s not that sadder people are less creative than happier ones, but that an individual tends to be more creative when he or she is happier than when he or she is more miserable.
If you’re stressed, you can’t be the teacher or parent you want to be.
And, I can guarantee 100% that worrying about whether you’re a good enough parent will NOT improve your parenting – it will only make it worse.
Imperfect ≠ Worthless
Even the people you most respect make mistakes and have done things they regret.

EVERYONE makes mistakes. Everyone is imperfect.

Yet each of us is wonderful in our own way – despite being imperfect.

And you can be a TERRIFIC parent even though you aren’t the perfect parent.
Advice to Parents & Teachers:

RELAX
Your humanity is more important than your knowledge or skill or doing the textbook-perfect thing.
Your caring -- your openness to truly listen; being there for your child when he or she needs you - is more important than your knowledge or skill.
The Spirit rather than the Technique

Who would you rather listen to....
the musician who plays from the heart or the
musician with absolutely perfect technique
but no heart?

If you happen to do what the textbooks
cautions against, but if it come from the right
place, it will likely be fine.
Don’t have much money? Can’t afford the newest toys or gadgets? Relax. Your kids don’t need those things; what they need most is YOU.
What matters most in Early Childhood Education?

Not the # of children
Not the caregiver: children ratio
Not having the best materials
but the caring relationship between the teacher and the children

As international studies show (e.g., Melhuish, 1990 a & b)
The people who make a difference in your life are not the ones with the most credentials, the most money, or the most awards. They are the ones who care.

- Charles Schulz
And children need to understand that it’s okay to make mistakes; everyone makes mistakes.
Don’t worry about making mistakes. “Going wrong is just something you do on the way to going right.”
Anyone who has never made a mistake has never tried anything new.

- Albert Einstein
The only way to completely avoid mistakes is to stay with what you already know, to never try anything new, to stop growing.
When we find out we were right, we’re not learning anything new.

It is only when we are surprised -- when we were wrong -- that we learn something we didn’t know before.

I tell my students, “Don’t be disappointed when your hypothesis is disconfirmed! Be thrilled! Now we have the opportunity to learn something we didn’t know before!”
Children need to feel safe
...to push the limits of what they know,
...to venture into the unknown,
...to take the risk of making a mistake or of being wrong.
The need to know it is okay to make a mistake.

It’s extremely important not to embarrass a child.

Children can’t relax if they’re worried you might embarrass them.
One major source of stress for many children is feeling that they’re not smart enough, that they can’t learn, and will never succeed...
Children need to believe in themselves.
Two routes to that:

• They need to feel you believe in them - that you fully expect them to succeed.

&

• They need do-able challenges. They need opportunities to do things that enable them to see for themselves that they are capable.
It’s important to communicate loud and clear the faith and expectation that each child will succeed.
When a toddler falls while trying to walk, we would never say ....
“You get a ‘D’ in walking today;” it would never occur to us to say that. Instead we say, “Don’t worry; I’m sure you’re going to be able to do this.”
How different is that from what children hear in school. They hear: “You get a D” instead of “There’s no question you are going to be able to do this. And we, together, are going to figure out a way to make that happen.”
Two routes to that:

• They need to feel you believe in them - that you fully expect them to succeed.

&

• They need do-able challenges. They need opportunities to do things that enable them to see for themselves that they are capable.
Through repeated experiences of "fail, exert effort, succeed" youths learn not to give up.
Give even young ones time to figure out things on their own.

Don’t intervene to help out too early.

SHOW that you have faith in the child.

Trust that there’s an excellent chance that he or she will be able to solve the problem on his or her own.
See video at:
www.devcogneuro.com/videos/PinkTower2.wmv
You've never failed until you've tried for the last time, and you've never lost until you quit.

-- Samuel Proctor Massie

It’s never over ‘til it’s over
Samuel Proctor Massie was born in the segregated South in the early 1900’s. You *know* he encountered a lot of discrimination, setbacks, and failures. Yet he rose to become one the most highly respected and decorated chemists of the 20th century.

You haven’t failed until you’ve stopped trying.
When you have exhausted all possibilities, remember this: ... you haven’t.

– Thomas Edison
Poverty is a stressor: Food, Housing, & Job Insecurity are each stressors.

Divorce, Death, or Strife within the Family are stressors.

Violence in the Home or Community are stressors.
It’s important to try to minimize stresses in children’s lives and in their parents’ lives and to give children and their parents better ways to handle the stress in their lives.
Born 12 weeks early, these twins were whisked into separate incubators. Brielle (on the left) had breathing and heart-rate problems, didn’t gain weight, and fussed when anyone tried to comfort her. Finally a nurse put the two sisters together. As Brielle dozed, Kyrie wrapped her arm around her smaller sibling. With her sister nearby, Brielle began to calm down and thrive. Sooner than expected, the girls went home.

first reported in the *Worcester Telegram & Gazette* Nov. 18, 1995
picked up by *Life Magazine*, June 1996
Hugs are superb medicine.
Pets can reduce stress
The presence of a dog in the classroom reduces stress and helps children perform better.


Employees’ dogs reduce stress in the workplace and make the job more satisfying for those with whom the dogs come in contact. The differences in perceived stress between days a dog was present or absent were significant.
Exercise Reduces Stress

Exercise in almost any form can act as a stress reliever.


Meditation can reduce stress.

Walking meditation is more age-appropriate for little kids than sitting meditation.
An activity from Montessori schools, that is essentially a type of walking meditation.

Everyone (even the grown-ups) gets a bell and walks in a line or circle. The goal is for no one’s bell to make a sound.
Our brains work better when we are not feeling lonely or socially isolated.

*Loneliness: Human Nature and the Need for Social Connection*
2008
a book by John Cacioppo & William Patrick

This is particularly true for PFC & EFs.
We are fundamentally social. We need to belong. We need to fit in & be liked. Children who are lonely or ostracized have more difficulty learning.
Roy Baumeister et al. (2002, *Journal of Personality and Social Psychology*) told a group of subjects that they’d have close relationships throughout their lives; - they told another group the opposite; & - told a third group unrelated bad news.

On simple memorization questions (that don’t require EFs) the groups were comparable. On logical reasoning (that requires EFs), those told to expect that they’ll be lonely performed worse.
Other researchers haven’t tried to manipulate this, but simply give subjects a survey when they come into the lab that includes questions like ‘Do you feel socially supported? Do they feel lonely?’

One research group (Campbell et al., 2006) found that prefrontal cortex functioned less efficiently in those who felt lonely or isolated.
We are fundamentally social.
We need to belong.
We need to fit in & be liked.
Children who are lonely or ostracized will have more difficulty learning.
It’s not just peers; a close relationship with a caring adult can be huge.
We are not just intellects, we have emotions, we have social needs, & we have bodies.
You need your sleep.
Lack of sleep will produce deficits in EF skills, and cause someone to look as if he or she has an EF impairment, like ADHD.
The brain doesn’t recognize the same sharp division between cognitive and motor function that we impose in our thinking.

The SAME or substantially overlapping brain systems subserve BOTH cognitive and motor function.
Motor development and cognitive development appear to be fundamentally intertwined.


Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex.

*Child Development, 71, 44-56*
For example, a brain region called the pre-SMA is important for sequential tasks, whether they are sequential motor tasks or sequential cognitive tasks.

Hanakawa et al., 2002
Most cognitive tasks that activate dorsolateral prefrontal cortex also activate the cerebellum (a classic motor area of the brain).

When dorsolateral prefrontal cortex activity increases so does activity in the contralateral cerebellum.

When dorsolateral prefrontal cortex activity decreases (e.g., when a task has been practiced and requires less concentration) so does cerebellar activation.

Activation in these two regions is strikingly correlated and closely coupled.
The different parts of the human being are fundamentally interrelated.

Each part (cognitive, spiritual, social, emotional, & physical) probably develops best when no part is neglected.

Diamond, 2007
I predict that those activities that most successfully improve executive functions will not only work on training and improving executive functions -- but also....
indirectly support executive functions by working to reduce things that impair executive functions and working to enhance things that support executive functions.
What activities directly train and challenge executive functions and indirectly support them by also addressing our social, emotional, and physical needs?
Traditional Activities that have been around for millennia.
For 10's of 1,000's of years, across all cultures, storytelling, dance, art, music & play have been part of the human condition.

People in all cultures made music, sang, danced, did sports, and played games. There are good reasons why those activities have lasted so long and arose everywhere.
Music-making, dance, and playing sports address our cognitive, emotional, social, & physical needs.
El Sistema Orchestra
National Dance Institute

Provided free. It takes all children (even those in wheelchairs). Has reached over half a million children in some of the poorest areas.
Because they challenge EFs directly, and indirectly support EFs by increasing joy, a sense of belonging, & physical exercise, I predict they should improve EFs.

(and we’re hoping to get funding to test my prediction for El Sistema Orchestra & for social, communal dance)
But, almost any activity could be the way in, the means for disciplining the mind and enhancing resilience.

MANY activities not yet studied might well improve EFs.
Key is that the child really enjoy the activity and really want to do it, so s/he will spend a lot of time at it, pushing him-or herself to improve.
Might as well have kids do something they can put their heart and soul into.
could be caring for an animal....
Could be a SERVICE ACTIVITY such as

Free the Children

Children Changing the World
More than 1.7 million youth involved in innovative education and development programs in 45 countries.

Educates, engages, and empowers young people to be confident young change-makers and lifelong active citizens.

Educators whose students are engaged in Free the Children report:

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>97%</td>
<td>of their students now believe they can make a difference in the world.</td>
</tr>
<tr>
<td>89%</td>
<td>confirm that their students are more confident in their goal-setting and completion.</td>
</tr>
<tr>
<td>85%</td>
<td>find a greater atmosphere of caring and compassion in the school.</td>
</tr>
<tr>
<td>90%</td>
<td>of their students have demonstrated increased leadership among their peers.</td>
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</tbody>
</table>
Research shows that what brings people the most happiness is not money or creature comforts, but making other people happy -- helping others -- seeing the smile on someone’s face because of something you did

Happiness runs in a circular motion.

Often, what makes us happiest is making others happy. Being kind to others is not only good for others; it is good for US -- it is the best route to genuine happiness.
“Sense of Purpose” Message

Encourages high school students to see and reflect on how working hard in school can help them accomplish meaningful, beyond-the-self goals, such as making the world a better place or contributing to their community.  

David Yeager
The Sense of Purpose Message is conveyed in a single 45-min session delivered online. Students were first asked to write briefly about how they wished the world could be a better place. It went on to provide info that many students work hard in school because they want to grow up to “make a positive impact on the world” or to “help their families.” Students were then asked to think about their own goals and to write about how learning and working hard in school could help them achieve those goals.

(Note that a component of this is having them USE the info. We learn thru action, not by simply listening.)
Paunesku et al. (Psychological Science, 2015) delivered this to about 400 students across heterogeneous high schools in 13 geographically diverse locations all across the US.

Among students at risk of dropping out of high school (the bottom 1/3 of the sample), this raised their GPAs in core academic courses and increased the percent of students performing at a satisfactory level in those courses.
Importantly, when students received a self-oriented purpose message very similar to the sense-of-purpose one, but…

putting forward a reason in the student’s own self-interest as a reason to work hard in school (e.g., to get a better job, to earn more money), there was NO effect on grades at all or any other measure of school performance.
That’s consistent with findings from other studies:

A pro-social message (where students are encouraged to think about how school might help them make a positive contribution to their family, community, or world at large) increases high school students’ willingness to do, persevere to complete, really boring school tasks that experimenters ask heir teachers to assign.

A self-oriented message (where students are encouraged to think about how working hard in school might help them earn a better income or get a better job) does nothing to help kids’ willingness to do and stick with boring tasks.
We have to care about the whole child (cognitive, social, emotional, spiritual & physical) if we want to improve any aspect (such as academics). If we focus only on academics, we are less likely to succeed.
If we ignore that a child is stressed, lonely, or not healthy because of poor nutrition, lack of sleep or lack of exercise, those unmet needs will work against achievement of our academic goals for our children.
To achieve the academic outcomes we all want...

- we need to try to reduce stresses in children’s lives & give them better tools to manage stress. Children need to do things that give them JOY.

- no child should feel alone; the classroom, the school community, and the wider community need to be supportive of our children.

- we have to care about children’s health -- they need good nutrition, sleep, exercise, & time outdoors.
While it may seem logical that if you want to improve academic outcomes you should concentrate on academic instruction alone, not everything that seems logical is correct.
Counterintuitively, the most efficient and effective strategy for advancing academic achievement is probably not to focus only on academics.
What nourishes the human spirit may also be best for Executive Functions.
Perhaps we can learn something from the traditional practices of people across many cultures & 1,000’s of years.

The arts, play, and physical activity may be critical for achieving the outcomes we all want for our children.
My thanks to the NIH (NIMH, NICHD, & NIDA), which has continuously funded our work since 1986, & to the Spencer Fdn, CFI, NSERC, & IES for recent support our work - and especially to all the members of my lab.
thanks so much for your attention

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Ways to help scaffold inhibitory control
Scaffolds enable children to function at a higher level than they otherwise would be able, and to practice skills they otherwise would not be able to practice.
A dad scaffolding his daughter to help her walk across a log high above a stream. With dad holding on, she’s able to walk across the log.
Young children’s impulsivity often leads them to answer right away rather than taking the time they need to formulate the response that they know is correct.

We can help them to wait before speaking or acting so they don’t impulsively react and answer too quickly.

(Instructing them to wait has little effect.)
THE DAY-NIGHT TASK
(Gerstadt, Hong, & Diamond, 1994)

Semantically conflicting labels

“Day”

“Night”

Requires holding 2 rules in mind, and inhibiting saying what the images really represent, saying the opposite instead.
DITTY

Experimenter sings a little ditty ♫ think about the answer, don’t tell me ♫ before the child responds.

Imposes time between presentation of stimulus and response to make children take the time they need to ‘compute’ the answer.
Percentage of Correct Responses by 4-Year-Old Children on the Ditty and Standard Conditions of the Day-Night Task

- **Ditty**: 89%
- **Standard**: 56%

Chance: ~90%
See VIDEO at:
www.devcogneuro.com/videos/daynight3.mov
Young children are often capable of responding correctly -- if some way can be found to cause them to delay responding for just a few moments.

Having them delay responding scaffolds their inchoate inhibitory abilities because by the time they can respond less inhibition is needed since their first impulse has now had time to begin to fade.
Get rid of mirror-reversal writing without fuss or tears. Leave a card showing a 6 drawn correctly for the child, and instruct the child that in doing his/her math today, every time he’s to write a 6 put down his pencil and pick up a red pencil (thereby imposing a delay). After 1 or 2 days of this, the mirror-reversal writing of the number 6 will be gone.
In the PATHS program, children are taught that when they get upset they should stop and hold themselves tightly with arms crossed (like a Turtle gets into its shell) and take a deep breath. This is brilliant. It imposes a short waiting period AND during that period it has children do things that reduce arousal & help them to calm down.
A way to help scaffold working memory
Non-verbal signs and symbols aid comprehension and memory.
I’m a huge fan of Storytelling
Storytelling requires and invites a child’s rapt attention for extended periods (sustained, focused attention), and, working memory to hold in mind all that has happened thus far, different characters’ identities, and to relate that to the new info being revealed - without visual aids.
A researcher (Gallets, 2005) randomly assigned children in Kindergarten & Grade 1 to storytelling or story-reading -- 2x a week for 12 weeks. Vocabulary and recall improved more in the children assigned to STORYTELLING than in children assigned to story-reading.
The conversation that takes place in the context of reading seems to have more benefit than the reading itself.


The more interaction, the more conversation between someone relating a story (thru reading or storytelling) & the children, the more actively engaged the children are, the more their vocabulary improves.
Maybe one reason is that when you are reading to, or with, a child you are looking down at the page at least part of the time.

But when you are telling a story you are looking directly at the children & interacting more.
You probably think, “Oh what a wonderful scene!”
I would like to suggest that young children also need this: STORYTELLING - where only the teller sees the pages in the book.

Without the visual aids of pictures, puppets, or video, children need to work harder to sustain their attention and to remember details of the story like who’s who in the story.

Note: You do not need to memorize the story. You can look at the book & then look up, but do not show the book to the children (at least not until the story is over).
Can bring in Elders from Native Communities, can bring in retirees from all communities, to tell stories to the children, to talk with them.
I predict that while Storytelling is wonderful, Storyreading should tax attention and working memory more and so should improve them more.
You may think that children need basic literacy skills to be ready for school.

They don’t.
Children need basic language skills to be ready for school.
Oral language is the foundation of early literacy (Paris & Paris, 2003; Kirkland and Patterson, 2005; Kendeou et al., 2009).

Young children need to be exposed to A LOT of RICH ORAL LANGUAGE.
The difference in the number of words that middle-income & low-income children HEAR in the US in the first 3 years of life is HUGE (25 million words).
By 3 years of age, children in the US whose parents are professional know more than twice (2x) as many words as children whose parents are on welfare.
Vocabulary assessed at age 3 strongly predicts reading comprehension at 9-10 years of age.

Over the course of evolution our brains became adapted to acquire oral language. **We are biologically predisposed** to acquire oral language.

But reading is too new; we have no biological predisposition for that.
Some children can easily learn to read at an early age. But critically, for others it is beyond their ability at that young age.

We don’t want children thinking they are failures.

We want children to LOVE learning & enjoy school, not to feel that they can’t learn & hate school.
AVOID children having failure experiences.

Hold off on requiring that 4, 5, or 6 year olds be able to read.
And, those who could have easily learned to read early, will make up completely for any lost time when reading is introduced, precisely because it comes more easily to them.

Ex.: Finland -- They don’t have children start school or begin to learn to read until they are 7. Finnish children score the best of any children in the entire world in PISA testing.
Very often what produces the best short-term outcomes is different from what produces the best long-term outcomes.

Rosenbaum et al., 2001; many papers by Robert Bjork’s lab 2007-2012
For example, high-stakes standardized exams produce poorer longterm learning.

Teachers told to insure that their students perform well on a high-stakes exam end up having students who perform worse in the long run than teachers given the mandate to facilitate student learning.

(Flink, Boggiano, & Barrett, 1990; Flink et al., 1992)
Children drilled in reading in K will test better on reading at the end of K than children steeped in oral language in K (who haven’t received the same instruction in reading),
but I predict that by the end of 2\textsuperscript{nd} grade, those steeped in oral language in K will be the better readers.
Do NOT push academics in preschool or kindergarten.

Do NOT push Literacy in preschool or kindergarten.