Executive Functioning Skills: The Importance of Visualization and Internalized Language in Learning and Life

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Amy Miller’s Disclosures

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Primary References

- Fahy, Jill (2014). Language and Executive Functions: Self Talk for Self Regulation. Department of Communications Disorders and Sciences, Eastern Illinois University, Charleston, IL.
What is Executive Function?

those cognitive abilities needed for goal-directed action

Barkley’s Definition of Executive Functioning

*EF is the use of self-directed actions (forms of self-regulation) to choose goals, and to select, enact, and sustain actions across time toward those goals, usually in the context of others and often relying on social and cultural means. This is done for the maximization of one’s longer-term welfare as the person defines that to be.*

(Barkley, 2012)

So, what happens if we don’t have executive functioning skills?
The Case of Phineas Gage

- Railroad worker injured when a tamping iron blasted through his skull in an accident
- The iron penetrated the left frontal hemisphere and exited the top of his head

Effect of injury:

"The equilibrium or balance, so to speak, between his intellectual faculties and animal propensities, seems to have been destroyed. He is fidgety, irritable, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellow men, impatient of restraint or advice when it conflicts with his own inclinations, devises, at times perversely obstinate, yet capricious and vacillating, devising many plans of future operations, which are no sooner arranged than they are abandoned in turn for others appearing more feasible. A child in his intellectual capacity and manifestations, he has the animal passions of a strong man. Previous to his injury, although self-taught in the schools, he displayed a well-balanced mind, and was looked upon by those who knew him as a shrewd, smart business man, very energetic and persistent in executing all his plans of operation. In this regard his mind was radically changed, so decidedly that his friends and acquaintances said he was "no longer Gage".

Observation by his doctor, Harlow, widely quoted.

The implications of Gage’s injury:

- Gage’s brain injury resulted in an “imbalanced brain”
- Unable to employ the self-regulatory skills necessary to meet the obligations of his life
- If a person’s brain, through injury or developmental difference, does not develop the capacity for goal-directed behavior that “overcomes the animal brain”, outcomes as an adult are limited
Why do some people have strong executive functioning skills and others don't? (Assuming they haven’t suffered a brain injury)

2 Key Components of EF Development:
- Self-Talk/Internalized Language
- Visualization

Components of Effective EF skills:
1. Problem Representation: requires attention, inhibition, and shifting for accurate representation of reality
2. Planning: encompasses the systematic generation of potential plans, using language to describe and evaluate those plans and visualization of the goal
3. Execution: requires the conversion of a mental or verbal plan into action and goal attainment, keeping in mind rules or constraints
4. Evaluation: in order to recognize and correct errors. (Zelazo, Carter, Resnick, & Frye, 1997; Zelazo & Muller, 2002)
Self Talk

- Chomsky posits that language is essential for thought.
- We think about novel, complicated, and challenging things by “talking ourselves through it.”
- Vygotsky posits that language, particularly internalized speech, is essential for self-regulation.
- Self-talk allows us to tell ourselves the story of our lives, empowering us to sequence, categorize, and make meaning from experiences and events.
- Ultimately, the ability to internalize language is the ability to OWN our experience by shaping and transforming it into something meaningful.

Vygotsky’s Phases of Egocentric Speech

- Syncretism of Action: emotionally-based descriptions of demanding situations (“It’s too high!”—typically pre-k age).
- Reflecting/Accompaniment: about 5 years old—emergence of language to guide behavior rather than to just describe a situation (spoken out loud as a support for behavior).
- Verbal Planning: 5-7 years old: language used for developing a plan—this then leads to inner speech or “speech thinking.”

Syncretism of Action

- It’s Too Heavy—Two Year Old having a tantrum!
Reflecting/Accompaniment

Verbal Planning

In these examples, how does the use of language lead to self-regulation, ownership, and ultimately, the making of meaning for these children?
Importance of Self-Talk

- “Speech thinking” or self talk allows us to shift our thinking from describing the present moment to reflecting on the past or planning for the future (first, then, next, after that, before that) - GOAL ORIENTED and TIME BASED
- Bronowski (1977) suggested that it is the presence of language in conjunction with behavioral inhibition and emotional disengagement which allow for reflection and planning, hypothesis testing, future thinking, and outcome anticipation

Recursion

- Recursion: the idea that the syntax of language can build on itself indefinitely
- Recursion allows us to build on the complexity of a thought without deviating from the syntax of a given sentence
- Without recursion, humans wouldn’t be able to view separate thoughts as subordinate parts of a complex idea
  1. This is the house that Jack built.
  2. This is the malt that lay on the floor in the house that Jack built.
  3. This is the rat that ate the malt that lay on the floor in the house that Jack built.

Recursion and Sequence: Time Based Thinking

- Chomsky argues that recursion is an essential feature of all languages, what he calls “natural language”
- If a brain has the capacity to think in this “natural syntax”, it innately has the capacity to sequence things logically based on that syntax:
  1. First, Jack built the house
  2. Next he built the floor
  3. Then he put the malt on the floor
  4. Then the rat at the malt on the floor

1. This is the house that Jack built.
2. This is the malt that lay on the floor in the house that Jack built.
3. This is the rat that ate the malt that lay on the floor in the house that Jack built.
But what if not everybody shares this innate capacity for "natural language"?

- Everett has argued that the Piraha tribe's language does not use recursion
- He also says it does not have past tense verbs
- Their language does not use subordinate clauses like, "When I am finished eating," or "after the sun goes down"
- No words for numbers other than 1 and many
- All of these things suggest that this tribe does not have the language to describe time-based or quantity-based concepts:
  1. They have no historical documents
  2. No calendars or clocks
  3. No creation myths
  4. No art for art’s sake
  5. When given tests related to basic mathematical concepts, “how many monkeys are in the trees?”, not one member of the Piraha tribe could do it
  6. When asked “did you see a monkey on the screen yesterday”, not one Piraha tribe member answered the question, although they all had.

Without internalized language, like the Piraha, we exist in the eternal present moment—we have no “sense of time”

In our culture, a “sense of time” and the ability to construct meaning is critical for success and survival

Much focus has been given in recent years to the concepts of “grit” and “growth mindset” as essential qualities for success.

- Can a person have “grit” without self-talk and visualization?
- If I cannot visualize what “done” looks like, what am I sticking to again?
- If I cannot “talk myself through it” and ultimately make personal meaning of my experiences, can I tell myself the story that I can “get better at something”?
- If I do not have an innate sense of time and of the relationship between things, the ability to understand and name categories, cause and effect, or to draw a conclusion about my own experience, can I really visualize myself achieving a goal that I haven’t internally articulated?
Effect of Language Disorders and Learning Differences

- Research demonstrates that adequate language is necessary for the development of regulatory self-speech.
- Children with language disorders and language based learning differences demonstrate significant delays in aspects of their language development.
- When language development is delayed, executive functioning skills are delayed.
  (Fahy, 2014)

Studies that correlate Language Development and EF

- Gioia, J., Isquith, P., Guy, S., & Kenworthy, L. (2000) found that 59% of children in the SLI group displayed clinical impairments in multiple EF scales, while only 27% of those in the typical language group presented with EF impairments, and in an average of only 2 scales.
- Hungerford & Gonyo (2007) found mean Global Executive Component (GEC) scores on the BRIEF for 17 children with SLI were indicative of core language performance on the CELF-4.
- Henry, Messer, and Nash (2011) found significant EF deficits in SLI population, and differences were not confined to the verbal EF tasks. Children with SLI performed less well than peers on nonverbal measures of EF, including nonverbal executive-loaded working memory, nonverbal fluency, nonverbal inhibition, and nonverbal planning.

Relationship between self-talk and EF success

- Winsler and Naglieri (2003) found that overt language in 5-year-old children completing complex planning tasks was gradually replaced by whispered language and finally silent, covert speech in 17-year-old children. Achievement in planning and other tasks was significantly related to the use of overt speech for the 5-year-old participants, while use of inner (covert) speech was significantly related to achievement and planning performance for the 13-year-old participants.
Novelty and Challenge and Overt Speech

- The more novel or challenging the task, the more likely even adults are to use overt speech.
- In a test using the Tower of London manipulative puzzle, as task difficulty progressed from simplest to moderate difficulty, so did private speech – both overt and covert forms – before declining again as tasks become so difficult they could not be achieved (Fernyhough and Fradley 2005).

Koziol’s Theory of the Linguistic Cerebellum

- Brain has seven complex networks that all must work together for us to process language and self-regulation.
- Language is not separate from sensory-motor functions; rather, it has evolved from these functions.
- The functions of these networks in relationship to the hemispheres of the brain allow us to engage with language in different ways.
- Cerebellum serves as the modulator, allowing for automatization of motor and language functions (Koziol, Barker, and Jansons, 2015).

Role of Cerebellum

- Cerebellum play the role of the modulator that serves the role of automating and adapting behavior across contexts (Koziol, et al, 2016).
Novelty-Routinization Principle

- left hemisphere governs routine behavior
- right hemisphere novel problem solving
- they have to work together in almost all situations (Goldberg & Costa, 1981; MacNeilage, Rogers, & Vallortigara, 2009)

Left Hemisphere

- literal
- procedural
- detailed
- Sequenced
- Routinized information

Right Hemisphere

- Metaphor
- Sarcasm
- Prosody
- humor
- all figurative language
- Synonyms
- Semantic connection
- understanding social cues/conversational context
Koziol’s Declarative/Procedural Model of Language

- “Declarative memory is an associative system for retaining facts and events, including the brain’s dictionary of words and the sounds and meanings of words” (Ullman, 2001).
- Procedural system serves the acquisition of new sensorimotor and cognitive habits, skills, and other procedures that require the “chunking” of sequences (Ullman, 2004).
- The learning and memory of this system is observed and/or measured through improvement in task performance.
- Learning new sequences tends to be gradual; it occurs in an ongoing way. This is why acquiring language is a gradual process. (Koziol, Barker, and Jansons, 2015)

Pezzulo’s Example of a Mechanic (2011)

- Mechanic learns to fix a car engine by doing.
- Once he practices these motor movements enough, his cerebellum can activate the same parts of the brain without the need to actually do it.
- Mechanic can now visualize and use language to talk himself through the procedure (his pre-frontal cortex has come on board).
- What started as sensory input has become semantic information.

Importance of Sequencing

- Koziol posits that at heart, language acquisition and executive functioning skills are about SEQUENCE.
- Grammar, syntax, temporal relationships, cause and effect, sorting into categories.
- Chomsky and others know that languages that use recursion are SEQUENCES. (Koziol, Barker, and Jansons, 2015)
The Internalization of Language in Dyslexia

- "The predictive and corrective mechanisms of the cerebellum generate the coordination and automatization of the sequencing of sounds and syllables into fast, rhythmically organized speech utterances resulting in words." (Koziol, 2015)
- Children with language based learning differences such as dyslexia have a relative weakness in brain networks related to phonological processing.
- "Therefore, the cerebellum has little cortically processed phonological information to copy for the purpose of performing its modulatory function." (Koziol, 2015)
- This contributes to difficulties with fluent reading and accurate spelling.
- They don't get enough rehearsal and modulation to make it automatic so it is as if they are experiencing language sounds for the first time every time!

Implications of Koziol’s model:

babies with imbalances in the sensory motor system/gross motor skills often grow into children with language delays or learning differences and teens and adults with executive function disorder!

A house built on a weak foundation cannot stand!
So, what should we do about it?
Building Internalized Speech and Visualization Skills in Children with language-based learning differences and language disorders

Overriding principle: Don’t assume they SHOULD know how to do this
- Children with ADHD demonstrate on average a 20-30% delay in brain development related to EF skills
- This means that the brain of a 12 year old with ADHD is functioning more like the brain of a 9 year old
- Children with language disorders and language-based learning differences demonstrate similar delays in EF skills, although some skills may be stronger than others
  - (Barkley, 2011)

The EFs Create Four Developmental Transitions in What is Controlling Behavior (Barkley, 2013)
- External to Mental (private or internal)
- Others to Self
- Temporal now to Anticipated future
- Immediate to Delayed gratification
  - (Decreased Temporal Discounting of Delayed Consequences)
2 EF Categories (Barkley, 2013)

**EF Comprises a Single Domain that Can Be Usefully Subdivided into two Broad Dimensions**

*Inhibition:*
- Motor
- Verbal
- Cognitive & Emotional

*Meta-Cognition:*
- Nonverbal WM
- Verbal WM
- Planning/Problem-solving
- Emotional self-regulation

What are the error profiles in language, and what are the error profiles in EFs?

**INHIBITORY DEFICITS:**
- Is the EF system virtually hijacked by disinhibition or lack of self-awareness, such that goal-oriented planning is unattainable?
- Do EF deficits in inhibition disrupt the adherence to task-requirements or environmental constraints?
- Are EF deficits in inhibitory control disrupting any hope of retaining or formulating useful language?
- Is the child’s language system underutilized by virtue of disruptions in attention, working memory, inhibition, or shifting (e.g., What rules? What instructions? What goal? Do now! Think later; plans and predictions are irrelevant).

***NEED FOR ATTENTION OR SENSORY INTERVENTION!***

**Metacognitive Deficits:**
- Does the child have a sufficient metacognitive vocabulary for use in thoughtful planning and prediction (e.g., know, think, deduce, predict, plan, first, then, after, last, etc.)?
- Can the child use metacognitive verbs, temporal concepts, and conditional adverbs to formulate syntactic necessary for cause and effect, deduction, and prediction? **NEED TO TEACH SEQUENCING, SENSE OF TIME, GRAMMAR, AND SENTENCE STRUCTURE**
- Can the child access and use relevant semantic features to compare various classes of items, or recognize how actions upon an object will impact that object? **NEED TO TEACH VISUALIZATION STRATEGIES**
- Are complex narratives disrupted by deficits in executive planning, organization, or inhibition? False starts, revisions, temporal disruption, and poor cohesion may materialize as the child attempts to use otherwise intact language systems at the level required for narrative explanations, instructions, or recounting. **NEED TO TEACH VISUALIZATION STRATEGIES**

*(Fahy, 2014)*
Use Hands-On, Multi-Sensory Learning

- Vygotsky observed that those with language deficits learn best through their hands
- Kozioł would say this is because they need to activate the cerebellum through motor movement which can be proceduralized and made automatic

Montessori: didactic, sequenced, multi-sensory materials

MACAR: Montessori Applied to Children At Risk

- Developed by June Shelton and Joyce Pickering, SLP/CCC, CALT/Q, LDT, AME-EC, HUM 2 at Shelton School of Dallas
- Implemented at May Center for Learning in Santa Fe
- Takes materials and principles of Montessori and pairs them with best practices for the education of children with language-based learning differences such as dyslexia
- Multi-sensory, systematic, explicit, diagnostic, and individualized in methodology
MACAR classrooms create what Barkley calls a “prosthetic environment” for those with EF deficits

- Focus on language development across curricular areas
- Procedural knowledge is explicitly taught, rehearsed, and reflected upon for all aspects of classroom culture

Key Components of “Prosthetic Environment”

- Make the abstract concrete
- Use “road maps” to support visualization of expectations, procedures, and sequences
- Always provide an example of what “done” looks like
- Teacher models self-talk out loud
- Provide students with mad-libs and scripts to anchor self-talk
- Use immediate, visual feedback for behavior management
- Do not assume that students “should” know anything!

Conclusions

- The development of the sensory-motor system and the language system follow similar networks in the brain, and both rely on the cerebellum for modulation
- Children with sensory-motor delays often also demonstrate language delays
- Language delays or language-based learning difference are correlated with deficits in executive functioning skills
Conclusions

- Internalized language or “self-talk” and visualization are essential components of the executive function system.
- Students who lack “self-talk” and visualization also lack a sense of time, the ability to categorize and sequence, and ultimately, the ability to make personal meaning from their experiences.

Conclusions

- A house built on a weak foundation cannot stand.
- Children must have appropriate and timely support in areas of sensory-motor, language, and EF development.
- Effective support provides a “prosthetic environment” that is multi-sensory and hands-on, systematic, explicit, diagnostic, and individualized.
- Without these supports, our students will never develop “grit” or “growth mindset.”
- Do not assume that a child “should” know this stuff—teach the child sitting in the chair!