Honors Undergraduate Thesis Project
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Title:
Developing Executive Function Skills in Children & Subsequent Impact on Vocabulary Learning

Abstract:
Aims: This study aims to further the current knowledge base by exploring the impacts of EF-stimulating activities on vocabulary expansion in kindergarteners. Secondary aims include the creation of a resource to distribute relevant information concerning executive function to families and caregivers. Executive function (EF) skills are necessary for effective problem-solving and planning, critical to healthy childhood development, and relevant to academic success. These skills can be developed over time, and EF is known to strongly correlate with language skills. However, the relationship between EF and specific language skills such as vocabulary learning are unclear.
Methods: 7 typically developing children aged 4 to 6 years participated in vocabulary tasks and activities designed to stimulate EF skills during a 6-week period in their University affiliated after-school program. During the 3 week control phase, a vocabulary assessment was administered prior to and following exposure to a series of new vocabulary words. Individual EF levels were also assessed (via DCCS task, Flanker test). Following the control period, children engaged in 3 different EF-stimulating classroom activities and were again exposed to a similarly balanced set of vocabulary terms over the course of 3 weeks. Each participant's pre- vs. post-training performance on EF tasks and vocabulary assessments were then compared.
Results: While the resultant impact of EF-stimulation on vocabulary learning was largely non-significant, marginal increases in both measures of executive function level were observed over time. Results showed trends of increased EF levels after participation in EF-stimulating activities, supporting the potential efficacy and validity of the selected activities as tasks which might be used to increase EF skills.
This further supports the feasibility of implementing EF tasks with preschoolers and concludes that such tasks can be effectively completed in a classroom setting.
Conclusions: Informing parents and caregivers of the positive developmental implications of executive functioning skills is important, especially given the potential for long-lasting positive effects. These skills can be developed both in home and school settings, and this study aims to provide families with a relevant resource guide of tested activities to better equip children for success.

Introduction:

Executive function (EF) is a term which encompasses a broad range of processes including mental flexibility, working memory, inhibitory control, and central coherence (Stemmer & Whitaker, 2008). Together, these skills can be thought of as a 'control center'; they are the explicit skills which allow us to engage in goal-directed behavior, control impulses, and flexibly shift attention between tasks.

Specifically, *mental flexibility* is what allows us to effectively consider multiple types of information at the same time, shifting our attention as needed. *Inhibitory control* refers to the ability to avoid distractions, inhibit impulsive actions, and maintain selective attention. *Central coherence* is considered relevant to the ability to see the 'big picture', as well as the utilization of *working memory* to follow multiple steps in the proper order to reach a desired goal. These skills are important to healthy childhood development, relevant to academic success, and known to have lasting effects through adolescence and even adulthood (Eakin, et al., 2004).

Prior work suggests that EF tends to increase naturally as a child ages (Huizinga et al., 2006). In addition, just as a muscle becomes stronger with use, EF skills can also be trained to increase over time simply through stimulation and continual use (Jacob & Parkinson, 2015). For example, engagement in activities that inhibit inappropriate impulsivity, encourage the use of mental flexibility, and/or utilize working memory can be utilized to exercise and build EF skills.

Further developing a child's EF skills could have many positive implications. It is no secret that children who are able to control their impulses, focus attention on a task, and articulate their needs are more likely to thrive in early education settings (Guernsey, 2019). Recent research also suggests that children with language-specific deficits might specifically benefit from the development of EF skills (Sun, et al., 2017). This reinforces the idea that EF ability and language skills are interconnected. For both typically developing children and those with developmental deficits, further exploration into interventionary EF activities arguably represents an effective use of time and resources.

While higher EF levels have previously been correlated with higher language skills (Gooch et al., 2016), the extent to which a specific skill like vocabulary learning might be impacted remains unknown. The purpose of this study is to determine the feasibility of implementing specific group activities to stimulate EF skills, and to further explore the impacts of such activities on vocabulary expansion in kindergarteners. The activities utilized in this study aimed to specifically incorporate *mental flexibilit*y and *working memory* by encouraging participants to sort stimuli with intermittently changing criterion. Additionally, *inhibitory control* was incorporated through activities which required following multi-step directions in order while refraining from impulsive actions. The study aimed to determine whether participation in these activities might increase individual vocabulary retention as well as increase EF scores over time.

While this study incorporates a classroom setting to implement EF-stimulating activities, building EF skills is not limited to a school setting, and effective implementation certainly does

not require a teacher, researcher, or therapist. Many of the most effective forms of developmental intervention have been found to occur in the home environment, with the involvement of a parent or caregiver. As such, the secondary aim of this study is to provide an informative resource in which activities and tips relevant to the development of EF skills in early childhood might be conveyed. Knowing the lasting implications of EF skill development in general as well as its increasingly well-backed impact on child language skills, providing accurate resources of tested activities that can be utilized in any setting is invaluable.

Methods:

This study was conducted at the Oklahoma State University (OSU) Family Resource Center. The study was reviewed and approved as exempt by the Institutional Review Board (IRB). All components of the study complied with the Center's regular after school programming guidelines (i.e. the EF-stimulating activities were in alignment with the Center's regular lesson-planning requirements). Parents/caretakers of participants were informed of the content of the study's activities in advance and given the opportunity to withdraw their children from participating at any time. The study utilized a quasi-experimental design in which every child was his/her own 'control'.

Participants:

A convenience sample was utilized for the purposes of this study. There were 10 students enrolled in the "Kindergarten Kids Club" (KKC) after-school program at the time of the study's completion, and the data included within this report includes all 10 children. However, due to absences, only 7 children participated in all 3 activities designed to stimulate EF skills. Those 7 were able to be tested individually at each time point (via DCCS, Flanker, and vocabulary assessment) and thus only those 7 children were included in the repeated measures analyses.

Each of the students in this class attended a daily kindergarten class prior to attending the after-school program. The children in this sample all lived within OSU's Family and Graduate Student Housing, meaning that at least one member of each family represented in this study is or was enrolled as a graduate student at OSU at the time of the study's commencement. Enrollment in after-school programming is free of charge to residents. All of the study's participants were multilingual individuals. The participants' ages ranged from 4-6 years of age. The total sample included in the repeated measures analysis consisted of 5 males and 2 females.

Procedures:

Executive function ability was assessed via both the Dimensional Change Card Sort (DCCS) task (Zelazo, 2006) and a child-specific version of the Flanker test (McDermott et al., 2007) in both the pre- and post- EF stimulation periods. Both the DCCS and Flanker tasks were administered individually in an on-paper format. The standard card sorting stimuli (rabbits and boats) were utilized for the DCCS task, and the specific administration guidelines of Zelazo's original study were followed for each participant (2006). Similarly, the Flanker task was administered according to the guidelines set forth by McDermott et al., (2007). To assess

vocabulary learning, standard 5-word multiple choice vocabulary assessments were also conducted before and after the control period, and before and after the experimental period. Vocabulary words were selected for their difficulty level. All words utilized fell in the 8-10-year-old typical age of acquisition in hopes of avoiding vocabulary words the students might have already known (Kuperman, Stadthagen-Gonzalez, & Brysbaert, 2012). All assessments were presented visually with pictures, and verbal instructions/ prompts were simultaneously provided.

The study in its entirety consisted of 6 sessions, occurring on 6 consecutive Fridays during the spring 2020 semester of the Family Resource Center's regularly scheduled after-school program. The succession of each session is detailed below.

Control Period: Sessions 1-3

During *Sessions 1-3*, participants engaged in their normal after-school program routines and lessons. An initial baseline assessment of executive function was conducted during *Session 1*, using the DCCS task and the Flanker test. An initial vocabulary assessment was also conducted. The vocabulary assessment utilized a standard multiple choice assessment format. Participants were presented with 5 multiple choice questions, each consisting of 5 images. After having been provided with several visual examples to ensure comprehension of task, each participant was verbally prompted to circle and/or point to a given term (shown below).

As part of each control session (*Sessions 1, 2,* and *3*) participants were exposed to the 5 newly assessed vocabulary terms in the form of a storybook, *Story Flipbook 1*. For consistency, the flipbook consisted of the same images that were utilized in the vocabulary assessment. The experimenter then told a story which incorporated each vocabulary word, actively engaging the participants by asking questions and labelling each image correctly as part of the storytime activity.

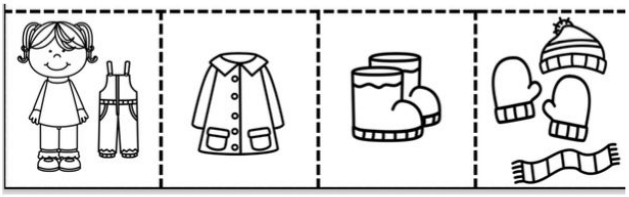
At the end of *Session 3*, participants' vocabulary retention and EF skill level were reassessed using the same methods as before. This final EF assessment also served as the baseline measure for the experimental period, as detailed below.

Experimental Period: Sessions 4-6

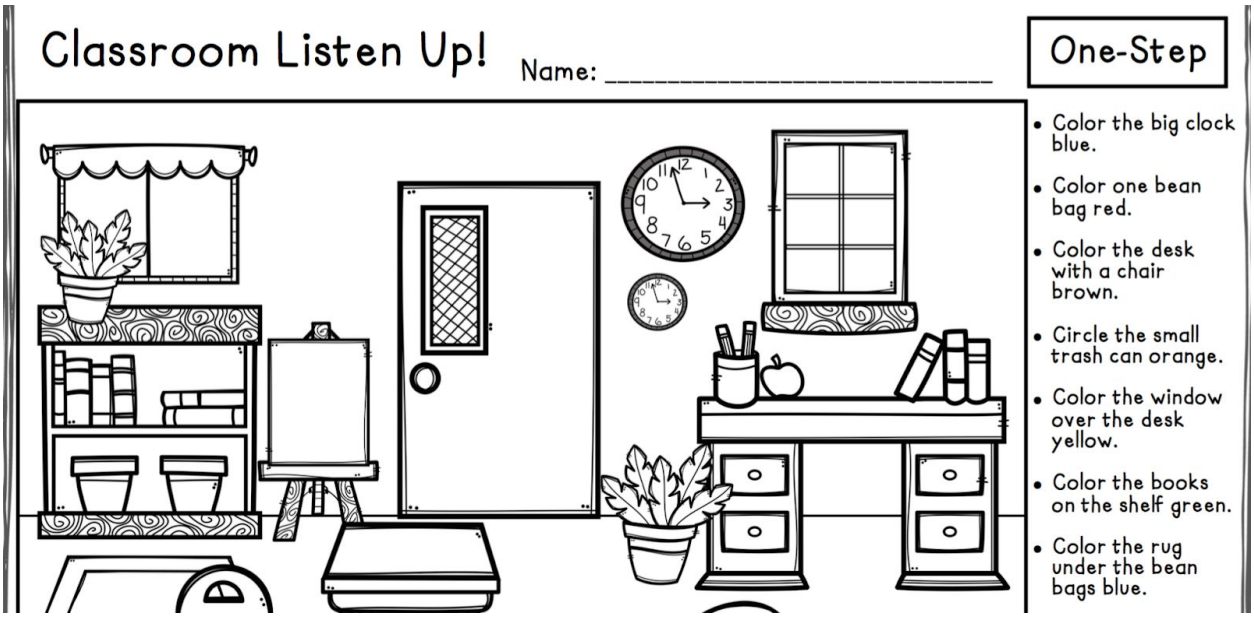
Session 4 began with a similar baseline assessment of a new vocabulary set (consisting of 5 new terms matched in difficulty level to those in sessions 1-3). This was followed by exposure to *EF Activity 1*, a sequencing activity aimed at exercising inhibitory control and the utilization of working memory skills. After being read a short story sequence, the participants were asked to arrange magnetic story cards in sequential order based on the sequence of the story (Figure 2). The participants were then read to from *Story Flipbook 2*, exposing them to the 5 new target vocabulary words in the same manner as before.

Jenny needed to find her winter clothes before she could go outside in the snow. First she found her snow pants. Next she found her long winter coat. Then she found her snow boots. Last she found her stocking hat, scarf and mittens. All these clothes would keep her warm.

Figure 2



Session 5 followed a similar format, beginning with exposure to *EF Activity 2*. This coloring activity required the children to follow multi-step directions in a specific order, exercising listening skills, focused attention, and inhibitory control skills. Participants were provided with a coloring sheet and asked, for example, to "color the biggest desk blue". To encourage mental flexibility, participants were also asked to shift their attention and perform unexpected tasks throughout the activity as well; i.e. "Everybody freeze!" or "When you finish coloring the chair, put your crayon on top of your head!". The activity was followed by storytime with *Story Flipbook 2* as before.



Session 6: Participants engaged in *EF Activity 3*, a group sorting activity which required identifying "Which item doesn't belong?" and "Why?" for various sets of grouped items. Each set was presented in a field of 4, as shown in the figure below. Participants exercised inhibitory control by taking turns coming to the board to circle and/or point to the non-belonging item rather than shouting out answers. This activity also encouraged mental flexibility by changing the sorting criterion from set to set, requiring the participants' focused attention to determine which item did not belong. For example, in one set, the non-belonging item differed in terms of its function/lexical category. But in the next set, the non-belonging item differed by color instead (Figure 3).

After a third and final exposure to *Story Flipbook 2*, participants' EF skills were again reassessed (via DCCS and Flanker) followed by a final vocabulary assessment. This concluded the experimental portion of the study.

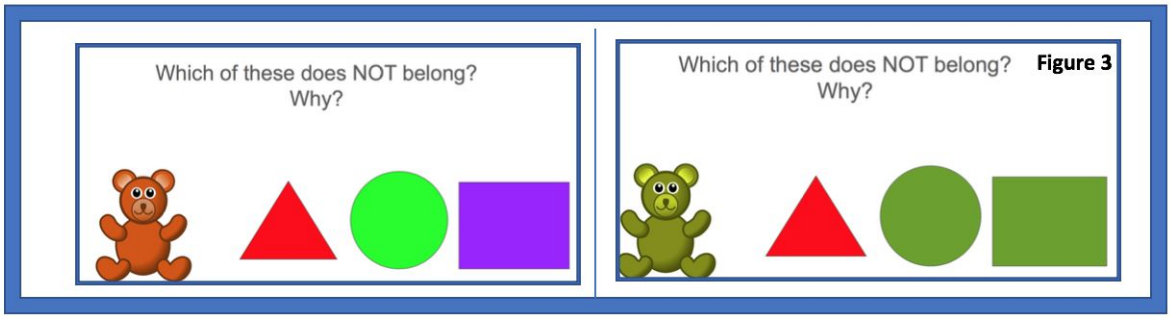


Figure 3

Results:

Table 1

SPSS Output Data

Task	t-value	p-value	Degrees of Freedom
EF Task- DCCS Test Change Score	-1.686	0.143[a]	6
EF Task- Flanker Test Change Score	-2.160	0.074[a]	6
Vocabulary Change Score	-0.415	0.695	5[b]

Note: This data was analyzed with IBM SPSS Software. Change scores represent the average control phase scores (pre EF-stimulation) subtracted from average experimental phase scores (post EF-stimulation) for each task.

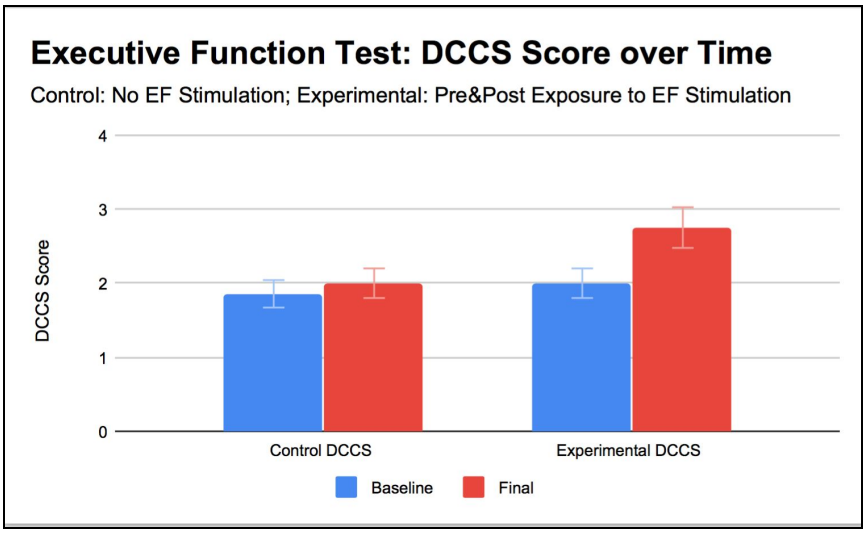
[a]Denotes marginal p-value results for the change scores of both tests of Executive Function, the DCCS p=0.143[a] and Flanker test p=0.074[a].

[b]Denotes a lowered degree of freedom for the Vocabulary Change Score: due to absences, only 6 children were present for each vocabulary assessment, hence the lower df shown.

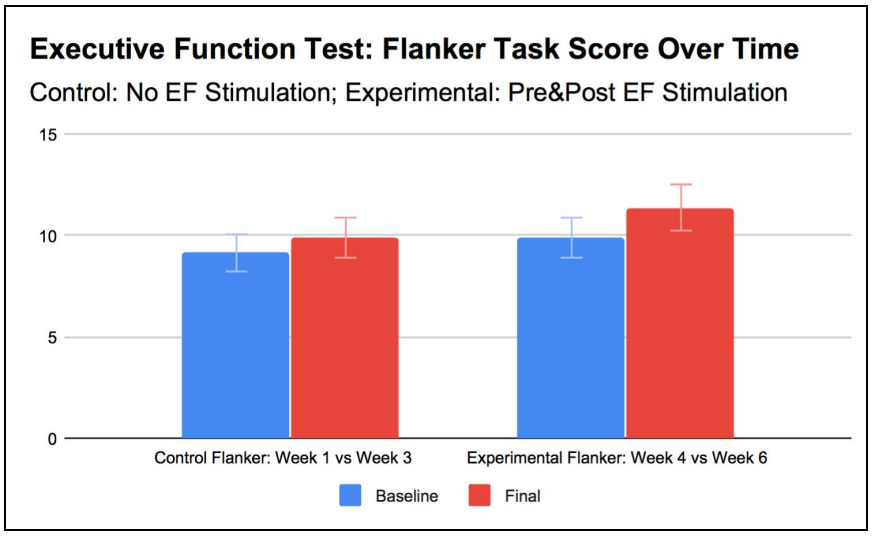
Pre vs. post training performance was evaluated through a within-groups t-test for each of the executive function (DCCS, Flanker) and vocabulary assessments, as shown above. Specifically, a change score was calculated for each participant and each respective test. For each individual, his/her pre-test score was subtracted from the corresponding post-test score. This allowed for comparison of all baseline change scores to EF change scores using the repeated measures t-test.

The graphs below represent this data, divided between the three measures utilized: Vocabulary, Flanker task, and Dimensional Change Card Sort Task scores. While none of the obtained p-values were statistically significant, both the Flanker task, $t(6)=-2.160$, $p=0.074$, and DCCS task, $t(6)=-1.686$, $p=0.143$, were marginal, implying the need for repeated measures and further exploration with a larger sample size.

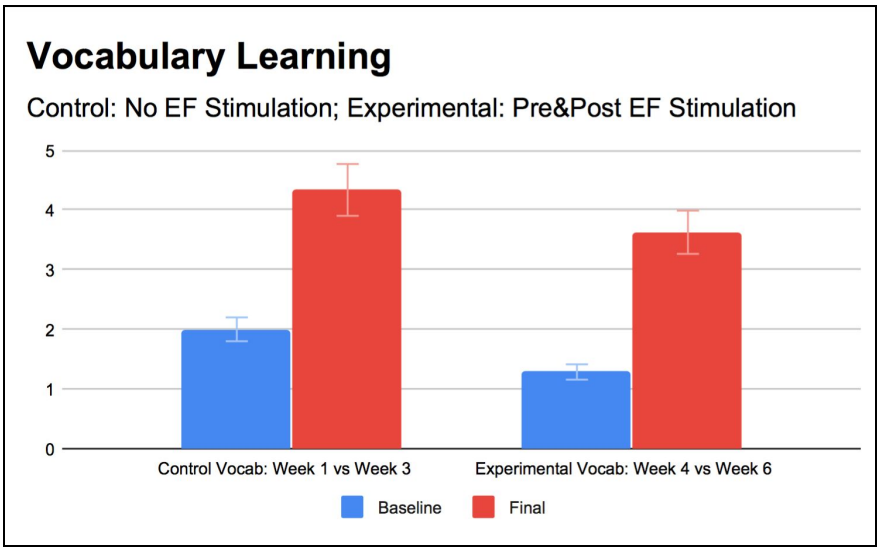
The vocabulary results, $t(5)=-4.15$, $p=0.695$, were not significant. As shown in the graph below, vocabulary scores increased in both the control and experimental settings both with and without exposure to EF stimulation, which accounts for the lack of significance displayed.



Note: Control DCCS- represents change in DCCS score before any exposure to EF-stimulation.
Experimental DCCS- represents change in DCCS score after 3 sessions of EF-stimulating activities.



Note: Control Flanker- change in Flanker task score before any exposure to EF-stimulation.
Experimental Flanker- change in Flanker task score after 3 sessions of EF-stimulating activities.



Note: Control Vocab- Average vocabulary assessment score before and after storybook exposure to Vocabulary Set 1. **Experimental Vocab**- Average vocabulary assessment score before and after storybook exposure to Vocabulary Set 2 and after completing 3 sessions of EF-stimulating activities.

Discussion:

Analysis of Results/ Implications:

Overall, the lack of significance of the obtained data is considered due largely in part to the study's small sample size, the implications of which are further discussed below. However, the trending values obtained for both the DCCS and Flanker tasks do suggest that the activities utilized in this study might have a positive impact on individual EF levels. This is an important finding, given that these activities had not been empirically tested as EF-stimulating activities prior to being utilized in this study. The activities were selected for their encouragement of relevant EF-related skills, such as the aforementioned inhibition of impulses, mental flexibility, etc. and arguably many similar activities may also encourage the use of such skills.

EF tests scores marginally increased after exposure to the sequencing, following directions, and sorting activities utilized in this study. This means that similar pre-existing activities may also have positive implications for EF-stimulation therapy. Additionally, as these activities were presented and implemented to a group of children, this supports the idea that EF skills can be developed in a group setting. This is an area of research that has not yet been thoroughly explored. Given the lasting effects of well-developed EF skills and the potential implications for other common group settings such as in the classroom and group therapy, these are important findings.

Limitations:

This study fully recognizes the presence of various limitations, first and foremost being the use of a convenience sample and the subsequently small sample size. By default, studies such as this are limited by the small samples they represent, making their results less significant and potentially less generalizable across larger samples and settings. More conclusive results will thus require further exploration and repetition of similar work.

This sample was also unique due to its makeup of primarily multilingual participants. Multilingual children and adults have been known to possess higher executive function levels as well as higher language skills in general than their monolingual peers (Fan et al., 2015). As a result, the participants in this study may have performed differently in EF strengthening tasks and may have had higher EF and vocabulary assessment scores than other monolingual children of the same age. This does again imply a lower degree of generalizability than would be ideal for a study of this nature. However, since all of this study's participants were multilingual, any EF benefit due to bilingualism would at least have been equal across the board. The inclusion of multilingual participants also presents the potential detrimental effects of language related comprehension deficits. This could have influenced comprehension of vocabulary terms, the understanding of the study's various instructions/tasks, and/or performance on EF assessments.

The researchers hoped to account for this by utilizing visual aids in conjunction with verbal instruction during each task to ensure comprehension throughout the study's duration. However, it is impossible to know the degree to which each participant truly understood each task and directive.

Another relevant consideration is the difficulty of effectively ensuring the same level of engagement across participants during both the EF and storytime activities. This could have impacted individual assessment scores. In the future, this could be better accounted for by utilizing a more traditional one-on-one experimental style. One-on-one EF activities were not a feasible component in this study due to time constraints and the group nature of the after-school program. However, this study's utilization of a group setting helps solidify the idea that EF skills can be strengthened through the use of many styles of activities and in a variety of settings; a point which is integral to this study and arguably important to future work as well.

Future Directions:

The secondary focus of this study was to provide a parent-friendly resource of empirically tested, age-appropriate, developmentally beneficial EF-building activities for children. Informing parents and caregivers of the positive developmental implications of executive functioning skills is important, especially given the potential for long-lasting positive effects. Providing such resources also encourages family engagement in relevant activities, which is considered a critical component of child development at all ages and developmental levels.

Developing EF could help lengthen a child's attention span, strengthen the ability to monitor/regulate emotion, and even provide a base from which to scaffold for future academic success (Eakin, et al., 2004). These are integral skills for all children, whether typically or non-typically developing, but it is particularly important to consider the implications of EF training activities for children who have EF deficits.

EF deficits have consistently been found in children with Autism Spectrum Disorder (ASD) (Akbar, 2013) and Attention Deficit Hyperactivity Disorder, (ADHD) (Barkley, 1997) making interventionary activities that help develop EF skills a worthwhile treatment consideration for therapists and psychologists alike. Executive dysfunction is becoming increasingly prevalent, frequently co-occuring in disorders like autism and showing presence outside of pre-existing disorders as well (Anderson, 2002).

Additionally, EF deficits have been shown to co-occur in children with language impairments (Gooch et al., 2014, Henry, Messer, & Nash, 2012). Given the known impact of EF ability on language skills, EF intervention activities show extended relevance in the therapy setting to Speech Language Pathologists (SLPs) and Auditory/Verbal Therapists (AVTs). EF intervention has been utilized successfully in therapy with ASD clients (Kenworthy et al., 2014), and it is possible that clients with language delay/disorder related deficits including pragmatic skills, perspective taking, and the following of prosodic cues may be positively impacted with similar intervention strategies. Little literature yet exists documenting the use of EF intervention with children outside of an ASD diagnosis, warranting the continued exploration of EF and its many potential implications. As there is still dissension concerning whether EF skills impact language ability at all (Varanda, 2014) further research and exploration is certainly needed.

Developing the best evidence-based practices possible for children and their families is worth the investment of additional study. The many positive implications of EF training and development make this an exciting topic for future researchers to continue delving into, as well as a wealth of potential information to be distributed to families, therapists, teachers, and other healthcare professionals.

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