Building Brains Together

Older Adult Literature Review

August, 2023

Executive function (EF) refers to a group of top-down processes required to concentrate or pay attention and make decisions to carry out actions (Diamond, 2013; Jurado & Rosselli, 2007). EF requires effort- it involves regulation to resist temptation or avoid an automatic or instinct-driven response (Diamond, 2013). EF is often broken down into three broad categories or skills: inhibition, working memory, and cognitive flexibility (Diamond, 2013). From this brief description, there are countless examples of how EF is employed daily across the lifespan. As as adult, for example, when you decide what to wear, you might use working memory to recall the forecasted weather, your inhibition to not select your favourite short sleeve shirt, and instead wear a weather appropriate sweater, as well as your cognitive flexibility to plan to leave the house a bit earlier to avoid the rain that the weather forecast predicted that morning.

The vision of Building Brains Together is healthy, resilient children, families, and society. Part of our mission is to support and improve brain development- specifically development of executive function. During the first eight years of this non-profit organization we have developed evidence-based curriculum to promote executive function in preschool children by working with early childhood educators as well as parents (Gibb et al., 2021). Recently, we successfully launched and tested an adolescent curriculum, which we are analyzing the outcome of the first cohort in middle schools from the 2022/23 school year. As mentioned, EF skills undergo rapid development in two sensitive periods- during preschool ages, and during adolescence (Ferguson et al., 2021; Jurado & Rosselli, 2007; Laube et al., 2020). There is another period of significant change in executive function that occurs during the lifespan, and that is near the end of life, when research documents older adults experience neurological changes (deCarli et al., 2005; Hoffman & Morocco, 2018) which can result in loss or reduction of executive function capabilities (Clark et al., 2012; Ferguson et al., 2021; Hoffman & Morcom, 2018; Lee & Kim, 2022; West, 2017).

EF in seniors is linked to the ability to perform instrumental activities of daily living (Fan & Wong, 2019; Jurado & Rosselli, 2007; Insel et al., 2006), which are vital for maintaining independence (Cahn-Weiner, 2000; Clark et al., 2012). The risk of falls is also associated with EF (Kearney et al., 2013). EF skills also predict cognitive decline and symptoms of dementia before dementia scales register a significant change in capacity (Clark et al., 2012; Jurado & Rosselli, 2007). Clark et al. (2012) followed a group of 51 older adults for two years, and found that measures of inhibition and switching components of EF predicted which 15 seniors began to experience cognitive decline, as measured by the Stroop task and verbal fluency task. These

measures of changes and loss of EF skills corroborate the evidence from imaging studies that after the age of 50, most adults will experience a decrease in brain volume (deCarli et al., 2005; Hedmen et al., 2011), with the greatest loss occurring in the frontal lobe, an area tightly associated with EF (Jurado & Rosselli, 2007; West, 2017).

The purpose of this report is to share our research-based rationale for the core "games" or activities chosen for the 60+ Building Brains Together curriculum. The 60+ curriculum is created to mirror the program developed for preschool children and adolescents. Our goal is to present a set of ten simple games that are: accessible (require minimal materials, easily altered to match physical/mental capabilities), some can be played both alone or in small groups, scalable to accommodate large groups, and most importantly, evidence-based. Like the preschool and adolescent curriculum, the goal of this program is to choose games that target various components of EF, and do not require physical activity or a specific setting. This review focuses on research that integrates these types of activities, and as such, is not an exhaustive report on successful EF interventions in older adults. It is important to acknowledge that researchers consistently report many other interventions that successfully maintain healthy brain function, and these are valuable whether your brain is three months old, three years old, or 103 years old. Prime examples include physical activity, social engagement, or musical training. These great options (and other executive function-building activities) are not directly included as part of our curriculum because our goal is to present a set of accessible games and activities that can be done with minimal equipment and minimal movement. Previous research suggests there is immense value in presenting a gamified approach to any type of training, as it can increase enjoyment, adherence, as well as the effect size of the improvement (Koivisto et al., 2020). It is up to your brain/imagination to incorporate these other great elements into our curriculum!

Recent meta-analyses, reviews and studies examined interventions used in older adults that resulted in significant improvement in memory, and other EF skills (Abd-Alrazaq et al., 2022; Campos & Vasconcellos, 2022; Fan & Wong, 2019; Gates et al., 2011; Newborn et al., 2017). These results credit the idea that a simple weekly activity intervention, either paper-based or computer based may result in significant improvements in different EF skills, such as working memory (Campos & Vasconcellos, 2022; Chiu et al., 2017a), mental set shifting (Chiu et al., 2017a), visual spatial ability (Chiu et al., 2017b), attention (Chiu et al., 2017b), and memory (Chiu et al., 2017b, Fan & Wong, 2019).

Campos and Vasconcellos (2022) conducted a meta analysis on studies examining memory maintenance and training in Brazilian seniors. Their review covered many different classifications of other types of memory- working, episodic, semantic, and incidental (Campos & Vasconcellos, 2022). It is important to note that only working memory is associated with EF, and the other types of memory, episodic for example, are shown to have a distinctive neural base from working memory and respond uniquely to treatment and interventions compared to working memory/EF (Cacciaglia et al., 2018). Campos and Vasconcellos (2022) found little to no

significant improvements in working memory in the select nine studies which met the criteria of including full statistical data appropriate for a meta-analysis. It is important to consider the limitations discussed in the meta-analysis that contribute to these minimal improvements, such as a lack of reporting intervention protocols, a lack of details around administration of the interventions, and the heterogeneity of the interventions- including the amount of time spent with the experimental group, whether the intervention was administered to a group or on an individual basis, and the category of intervention, paper based versus electronic/computer based, etc.(Campos & Vasconcellos, 2022).

Fan and Wong (2019) present an excellent review of cognitive training in older adults with normal cognition as well as mild cognitive impairments. See the paper for a clear presentation of the studies reviewed:https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6787728/ Some generalized results in their review echo the findings of the other reviews discussed. In adults with normal cognition, multiple studies with heterogeneous cognitive training methods improved cognition as well as the adult's instrumental activities of daily living scores (Fan & Wong, 2019). An exciting finding is that the improvements in cognition and in the training task were maintained up to two years after the initial intervention (Fan & Wong, 2019). In adults with mild cognitive impairment, the same improvements were not observed. This effect was mirrored in other studies that examining older adults with mild to moderate cognitive decline (Kallio et al., 2018).

> Abd-Alrazaq et al., 2022 finds that computerized games did improve EF, but were not any more effective than other active or passive control groups.
>
> Metzler et al, 2023, saw an improvement in EF measures and other life measures including RT from completing daily training on a language learning app as well as a cognitive training app.

Gates et al. (2011) found similar findings to the previously described studies. There is wide variation between the methods used for cognitive training and intervention- the training sessions ranged in time from 1 hour up to 8 hours per week. Some studies included control groups, which completed a range of activities from passive/non-assigned activity to organized weekly group meetings. They analyzed effect sizes and found that memory had inconsistent improvement and the positive effects observed after the invention was commonly not maintained upon follow-up.

Notable results from Chiu et al. (2017b) include a focus on exclusively healthy seniors, attention to sub-factors that influence cognitive skills related to EF, and an openness to include studies published in other languages and age of the study. Chiu et al. (2017b) found 22 studies on EF training in seniors.

Participants spent an average of 17.66 cumulative hours in training (SD = 30.85, Mdn = 10.50, range = 1.00–270.00). Number of intervention sessions ranged from 1 to 180 (M = 19.80, SD = 22.05, Mdn = 12.00).

Intervention sessions lasted almost 1 h, on average (M = 0.90, SD = 0.47, Mdn = 0.75, range = 0.10–3.00) and typically occurred 2–3 times per week (M = 2.88, SD = 1.58, Mdn = 3.00, range = 1.00–7.00). Additionally, studies were equally as likely to deliver interventions individually (k = 109) as in groups (k = 95). Fewer studies used a mixture of individual and group formats (k = 15).- Newborn

Results showed that cognitive interventions were equally effective for cognitively healthy older adults and those with MCI. Intervention efficacy was not limited by age or educational attainment. Additionally, duration of the intervention and type of control group (i.e., active vs. passive) did not significantly impact results. Working memory interventions were the most effective, though memory, processing speed, and multi-domain interventions also produced positive results. Intervention gains were significant in terms of improving trained cognitive domains as well as far-transfer to non-trained domains. Other intervention characteristics, including total number of intervention sessions, duration and frequency of sessions, and intervention delivery format (individually vs. groups) influenced the main effect, but were not as impactful as other variables such as intervention domain and outcome domain (i.e., trained vs. transfer effects).

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Of the meta-analyses and review articles discussed here, a shared issue is the lack of details provided regarding the interventions for the older adults. This lack of information makes it impossible to replicate the methods and apply reportedly successful programs in other studies, or use with our organization. A second issue is the prevalence of computerized interventions. As we want our curriculum free and accessible to a population who may still be uncomfortable with technology, or unable to access technology, we did not see these interventions as relevant for our program. Another issue raised is the variability in the control group treatment. Some studies did not use a control group (Anand et al., 2011, Aramaki & Yassuda, 2011), which makes interpretation of the invention difficult. If the studies did utilize control groups, there is wide variability in the activities assigned to the control group, such as……. This means significant changes, or lack of significant changes may also be due to the nature of the control activity.

Kuo et al. (2018) shows the benefit of a social card-game intervention. Through a specifically designed set of card games, Kuo et al. (2018) demonstrated that even with a board-game social control group, a set of games designed to target EF significantly improved EF compared to the board-game control group as well as a waitlist control group. It is important to note that the board game control group also improved in EF measures during the post test, which suggests

that cultivating social experiences around these cognitive interventions may be as important as the intervention itself.

With the acknowledgement of the various obstacles facing the literature, we would like to highlight the following studies which did use a table-top intervention activity, included a control group, and found significant improvements in one or more components of EF.

Golino, M. T. S., & Flores-Mendoza, C. E. (2016)- detailed cognitive training program

Seniors and young adults use similar memory strategies, YA are just better (Fabricio & Yassuda, 2011).

Effects from a cognitive training program were maintained 18 months later (Aramaki & Yassuda, 2011). The maintenance of skills also lasted for at least 18 months after a computer based EF training program in older adults (Dahlin et al., 2008). HOwever, Dahlin et al. (2008) noted that the benefits observed in the training task did not transfer to improvements in other EF skills such as working memory, shifting, or inhibition.

Computer brain-training games did not improve working memory (Beckenham, 2021), but sometimes they did (Chiu et al., 2017) and not inhibition (Chiu et al., 2017) but did improve mental set shifting (Chiu et al., 2017).

ANother form of studied intervention that BBT included and discussed with young children is mindfulness based practices. A recent review suggests that a mindfulness based practice in seniors is not a surefire way to have the best benefits, but in controlled groups, mindfulness did result in significant improvements in EF, specifically working memory, compared to inactive controls. The benefits were not as consistent or noticeable compared to other inventions (Whitfield et al., 2022).

There are many other research based ways to improve and/or maintain EF. As described at the beginning of the review, these dimensions can be just as valuable and produce similar beneficial outcomes. Because they do not fit the scope of BBT, or the goals of our 60+ EF curriculum, some of these interventions are worth mentioning, but not directly included in the curriculum. The prime components linked to improving EF based on the literature review include exercise (Albinet et al., 2016;), musical training (Bugos et al., 2007), and increased socialization (Carlson et al., 2008). One additional method that is allegedly linked to improving EF is various online computer games and activities.

Exercising is valuable for maintaining and improving many domains of health and wellness, and some evidence suggests cognitive health is improved as well. This claim is more contentious, as outlined by Diamond and Ling (2019). A recent meta-analysis found exercise such as dance could improve mental state, but had no impact on measures of EF (Meng et al., 2020). Exercise is clearly linked to improving quality of life, reducing depression (Albinet et al., 2016), and maintaining performance of activities of daily living, including fine motor skills (Corti et al., 2017). Some of the noted positive cognitive effects include an increase in brain volume

(both grey and white matter; Colocombe et al., 2006). These positive effects are repeatedly demonstrated through experimental studies using control groups with activities like dancing (Chen et al., 2020), stretching (Albinet et al., 2016), yoga (Chen et al., 2020), swimming/aqua-aerobics (Albinet et al., 2016), resistance training (Chen et al., 2020; Liu-Ambrose et al., 2010) and aerobic exercise (Chen et al., 2020; Colcombe et al., 2006) to name a few. The interventions can range from 8 to 24 weeks(Albinet et al., 2016; Colcombe et al., 2006). A recent meta-analysis suggests that any exercise is beneficial for EF (Chen et al., 2020). Through the review of 33 randomized-controlled studies, Chen et al. noted the greatest positive effect on EF in older adults participating in moderate-frequency of training and specific types of exercise, with the greatest benefits arising from prolonged participation in the exercise program compared to shorter participation periods (Chen et al., 2020). Sedentary participants' EF benefitted the most from these training programs compared to already active participants, as did young-old adults (ages 55-65) and those with typical cognitive scores (Chen et al., 2020).

Much like exercise, musical training and/or exposure shows similar success as a way to maintain or improve not only EF, but other life-factors such as memory or motor skills (Bugos et al., 2007). These studies suggest that only one to three hours of weekly music practice in addition to a weekly lesson was effective for significantly improving EF compared to a control group (Bugos et al., 2007; Miyazaki & Mori, 2020). Alternatively, a few short sessions of listening to classical music presented improved EF (Mammarella et al, 2013).

A final component that is present in almost every intervention described in this review is the value of increased and meaningful social interactions. Social isolation is a significant predictor of various diseases such as Alzehimer's disease/dementia (Ballesteros et al., 2015), loss of ADL (REF), and finally, reduced EF (Ballesteros et al., 2015). All participants in the previously described studies increased their social circle, and especially by participating in an active control group or in the experimental group, likely increased the amount of social interaction in their lives. In studies that include socialization as a factor, there is a measurable increase in EF that arguably arises from the unique interactions that require participants to use planning, working memory, emotional control and other EFs (Carlson et al., 2008). In one study, seniors were invited to become "Experience Corps" and spent time at elementary schools to assist children with reading, provide library and classroom support for 15 hours/week (Carlson et al., 2008). The participants showed significant improvement in EF, despite never directly discussing or intentionally training EF skills with the experimenters. In many of the studies reporting a positive effect of exercise, including aerobic, strength training, and yoga interventions, it is also argued that it is the interaction more so than the exercise itself that is benefitting the participants (Diamond & Ling, 2019). Mewborn

Google scholar search terms:

Seniors play

Seniors play -videogames

seniors games executive function training

executive function older adults

working memory training seniors

cribbage improve senior executive function

card games improve senior executive function

card games improve older adult executive function

meditation and executive function in seniors

mindfulness and executive function in seniors

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Table 2 Gist reasoning training

Session	Strategy	Brief description	Instruction/Activity
			Each of the first four training sessions highlights one strategy. Since each strategy builds on the other, the training is additive in nature.
1	Inhibit	Deleting unimportant or extraneous information, allowing important information conveying global theme to emerge.	Read text more than once to get a general sense of what it is about. Delete extraneous information leaving ideas that go together to communicate important points. Using texts of high complexity, participants draw a line through information that is extraneous to its global theme. Read what remains to determine if more or less deletion is necessary.
2	Organize	Organizing of information into a purposeful sequence, by focusing on concepts, or themes abstracted from the text.	Chunk important information into own words to write down 2–3 key concepts to create a framework for summary of complex text.
3	Inference	Binding information across adjacent sentences/information units to fill in the gaps and read between lines.	Use inference to integrate the key concepts to write a concise synopsis of the text.
4	Generalize	Integrating newly encountered information in the context of life experience and world knowledge to construct broader meanings than conveyed by the explicit content.	Write down deeper meanings about text in relation to world knowledge with an eye toward innovation, creation, interpretation, multiple solutions, and diverse perspectives. Write down interpretive statement as a part of the summary.
5–8	All strategies		Apply all the above strategies to process information using gist reasoning when reading complex articles and books, watching movies and plays, attending art exhibits, and working on projects related to real-life activities.

Training strategy from Anand et al., 2016

Golino, M. T. S., & Flores-Mendoza, C. E. (2016). Development of a cognitive training program for the elderly. Revista Brasileira de Geriatria e Gerontologia, 19, 769-785. Training program from paper

Session 01			
Cognitive domains	Tasks	Description	No. of items
Concentrated attention and processing speed	Explaining attention	Information about what is attention, how this ability affects our routine and how we could improve it.	
	Game of seven errors	Identify differences between two figures;	7 items
	Mazes	Draw the correct path through a maze, without crossing over the lines, in a controlled time period; Repeat the same maze in half the time required to complete it the first time.	Easy – 3 items Medium – 3 items Difficult – 3 items

Session 02			
Cognitive domains	Tasks	Description	No. of items
Memorizing visual stimuli	Figures	Analyze a figure and reproduce it while looking at it; Analyze a figure and reproduce it without seeing it anymore.	Easy – 3 items Medium – 3 items Difficult – 2 items
	Cinema	Watch the short film "Soko" and answer questions about the story and characters	1 item

Session 03			
Cognitive domains	Tasks	Description	No. of items
Attention for auditory stimuli and episodic memory	Sound stimulation	Identify, in a set of sensual words, the one that is wrong or does not exist.	10 items
	Retelling stories	Listen carefully to a story, divide it into segments, retell the story partly, retell the story in its entirety.	Easy – 3 items Medium – 3 items Difficult – 3 items

Session 04			
Cognitive domains	Tasks	Description	No. of items
Concentrated attention and processing speed	Visual search	Mark the stimulus-target within a series of distractor stimuli, with controlled time; repeat the task in half the time required for the first attempt.	Easy – 3 items Medium – 3 items Difficult – 3 items
	Film	Discussion of the short film "Dona Cristina lost her memory".	1 item

Session 05			
Cognitive domains	Tasks	Description	No. of items
Episodic memory (strategy of mental visualization)	Visualization	Close your eyes and describe the room around you; look at the image of a house and when the image is no longer present, describe it.	2 items
	Photographs	Analyze personal photographs and once they are no longer visible, describe them and answer questions about them.	2 items
	Parts of the body	Imagine that each part of the body is transformed into a different object.	6 items
	Visualizing figures	Analyze figures and once they are gone, visualize them in your mind to answer questions about them.	3 items

Session 06			
Cognitive domains	Tasks	Description	No. of items
Episodic memory (strategy of idea association)	Idea association	Make associations to memorize tasks	3 items
	Implementing future actions	Imagine you are performing future actions	1 item
	Medicine	Make associations to memorize drugs	Variable in accordance with the number of drugs per participant
	Commitments	Make associations to memorize commitments	Variable in accordance with the number of commitments per participant

Session 07			
Cognitive domains	Tasks	Description	No. of items
Episodic memory	Memorizing names	Create different strategies to memorize the names of people	11 items

Session 08			
Episodic memory	Tasks	Description	No. of items
	Memorizing numbers	Create different strategies to memorize numbers	3 items
	Important numbers	Create different strategies to memorize important personal numbers	Variable in accordance with the number of important numbers per participant

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