AMERICAN UNIVERSITY OF BEIRUT

ADAPTATION AND VALIDATION OF BARKLEY DEFICITS IN EXECUTIVE FUNCTIONING SCALE FOR ADULTS IN A LEBANESE UNIVERSITY

by
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ABSTRACT

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Title: Adaptation and Validation of Barkley Deficits in Executive Functioning Scale for Adults in A Lebanese University

Executive functioning (EF) plays a crucial role in self-regulation across various aspects of life, yet its definition remains varied within literature. This study aims to validate and adapt the Barkley Deficits in Executive Functions Scale – Adults (Self-Rating scale) for assessing EF deficits in adults aged 18 to 33, particularly within the Lebanese context. Given the scarcity of EF research, especially in Lebanon, this exploratory study focuses on AUB students as a representative sample.

Using a descriptive quantitative research design, we adapted the BDEFS-A scale and obtained expert review. Although challenges hindered piloting, the adapted scale was administered to a normative sample, yielding a final sample of 52 participants. Reliability analysis showed moderate to high internal consistency ($\alpha = 0.43$ to $\alpha = 0.80$). Construct validity analyses revealed no significant gender or education effects on EF deficits. However, age effects varied across subscales. Discriminant validity analysis showed differences in EF deficits between ADHD and non-ADHD students. Norms were developed for each subscale.

Despite limitations, this study underscores the reliability and preliminary validity of the adapted BDEFS-A among AUB students. Further research is warranted to establish robust validity evidence and expand the sample size.

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ABBREVIATIONS

EF: Executive Function

BDEFS-A: Barkley Deficits in Executive Functioning Scale for Adults

CHAPTER 1

INTRODUCTION

This chapter identifies the research problem and provides a brief framework for the study in terms of the context, purpose and significance of the study, and the rationale for it.

Context

Executive functioning (EF) serves as an essential component for self-regulation, where its impact extends to several areas over the individual's lifetime including education, health, and wealth (Dehili et al., 2017; Diamond, 2013; Lezak, 1982; Vélez-Pastrana et al., 2016). Hence, assessing EF in individuals will indicate their abilities to perform certain tasks and the strategies that they could use to carry them out until completion (Lezak, 1982; Rivera et al., 2019).

Deficits in EF have been associated with numerous psychiatric and neuropsychological disorders (Lezak, 1982; Rivera et al., 2019; Vélez-Pastrana et al., 2016). Furthermore, the influence is two tailed between the deficits and the disorders; meaning that EF deficits could increase the chance of having a disorder and vice versa, EF deficits could be caused by the disorder(s) (Roukoz et al., 2021).

There is no consensus over the definition of EF up till now; literature provides us with multiple views on the understanding of EF (Barkley & Fischer, 2011; Vélez-Pastrana et al., 2016). Some view EF as the competency through which individuals develop the knowledge and skills that enable them to solve problems in different areas including attention, emotional regulation, organization and planning, self-control, and working memory (Dehili et al., 2017; Goldstein & Naglieri, 2014; Lezak, 1982). Princiotta et al.

(2014) defined EF as “the efficiency with which an individual applies his or her ability and knowledge in order to deal with everyday life” (p. 143). Others refer to EF as executive control and view it as a group of hierarchical cognitive processes that are activated when you engage in a task that requires concentration and paying attention (Diamond, 2013; Lezak, 1982; Roukoz et al., 2021), while some limit their definition to its components: planning, inhibition, flexibility, behavioral control, and strategy use…etc. (Barkley, 2001; Dehili et al., 2017; Roukoz et al., 2021). So when speaking of EF, one would be referring to a comprehensive term that includes several domains that Bueno et al. (2017) grouped as: 1) hot processes (including emotional and social behavioral processing), and 2) cold processes (including inhibition, suppression of information that are irrelevant to the current task, planning, and switching between multiple tasks).

With that said, we refer to EF in this study as a meta-construct that is measured by the individual’s competency in each of: time management, organization and problem solving, inhibition, motivation, and emotion regulation.

Research Problem

“Executive Functions” is emerging as a field by itself in neurosciences (Ardila, 2008) and educational psychology. The concept of executive function has first emerged, implicitly, in the 1840s, through the association that was made with the case study of Phineas Gage (Goldstein et al., 2014; Harlow, 1999). Phineas Gage was an American railroad construction foreman who was punctured with a large iron rod causing him a brain injury, specifically a damage in his left frontal lobe (Goldstein et al., 2014; Harlow, 1999; Ratiu & Talos, 2004). Then, he was perceived as a different individual due to the changes observed in his behavior and personality after his survival leading him to become a

hyperactive, irritable, and disinhibited person as described by many researchers (Goldstein et al., 2014; Ratiu & Talos, 2004). This has led to the researchers' investigation of the role of frontal lobes with respect to the executive functions.

It is important to note that the first definition was made by Pribram (1973) who referred to EF as executive programs in the brain primarily associated with the frontal lobes: "the frontal cortex appears critically involved in implementing executive programs when these are necessary to maintain brain organization in the face of insufficient redundancy in input processing and in the outcomes of behavior." (p. 312). Not only Pribram (1973) associated the prefrontal cortex with the executive functions made in the brain (Goldstein et al., 2014), but also Barkley (2011) has associated the "damage to the frontal lobes with a disruption in goal-directed behavior" which could be referred to as one aspect of EF deficits.

Most of the research examining the concept of executive functions focuses on the components that sum up the EFs separately (Goldstein et al., 2014). There are several perceptions that explain the concept of EF as discussed by Goldstein et al. (2014), this includes: a balance between automatic and controlled processes, cognitive control, supervisory attentional system, central executive (unified structure with multiple functions), cross temporal model (an alloy of planning, working memory, and interference control), and an extended phenotype (working memory, emotional management, problem solving, analyzing and synthesizing, self-monitoring, and self-motivation).

There has been a slow appearance of executive functions across research at the initial stages of emergence (Goldstein et al., 2014). However, there's increasing interest in investigating this issue today with an emphasis on the dysexecutive syndrome, which is

associated with, for some reason or other (e.g. brain injury), having deficits in EF (Dehili et al., 2017; Goldstein et al., 2014). To understand executive functions better, researchers often pose some questions that allow for the measurement of the construct. Some of the questions include: (1) how long can the individual sustain his attention on a task upon completion, with the presence of distractors? (2) how well can individuals shift their attention when there's a change in the demands of the task? (3) how often / how well does the individual initiate an EF task? (Bolden & Fillauer, 2020; Goldstein & Naglieri, 2014; Hildebrandt, 2018; Hofmann et al., 2012; Lezak, 1982).

Context of the problem

This section will discuss the rationale behind choosing the EF as construct to investigate and the BDEFS-A scale in particular to validate.

The importance of EF goes beyond academic success and social aspect; it stretches to every facet of life (Dehili et al., 2017; Diamond, 2013). This includes mental health, physical health, school readiness and success, career life, quality of life, and the list goes on (Dehili et al., 2017; Diamond, 2013). To illustrate, deficits in EF have been associated with mental disorders such as ADHD, depression, and poor academic achievement (Bueno et al., 2017; Dehili et al., 2017; Diamond, 2013; Rivera et al., 2019; Roukoz et al., 2021; Vélez-Pastrana et al., 2016). Deficits in EF are portrayed when you have individuals intending to do something, but end up doing something completely different (Diamond, 2013).

Hence, one can see that EFs are needed for the development of the twenty first century skills, such as creativity, self-control, and flexibility (Diamond, 2013). There is an increasing demand on these skills today, since we make use of them to cope with the

ongoing, abrupt changes and challenges that we are currently facing at this point of life (Dehili et al., 2017; Diamond, 2013).

Why Is It Important to Be Studied in Lebanon?

Lebanon is one of the countries that have a diverse population with regards to linguistic proficiency, socioeconomic status, beliefs, religions and sects (Roukoz et al., 2021). It is found to be short on studies about executive functions in general (Roukoz et al., 2021), with very few studies published on young populations only, mainly children and adolescents.

There are multiple tests and scales that have been developed in the western region to measure executive functioning (e.g. BRIEF, Brown EF scale) (Dehili et al., 2017). Within our Arab region, we lack the construction of these scales that would fit in our setting, and take into consideration the cultural norms, differences in language, socioeconomic backgrounds, and environmental factors that could influence the executive functions of our populations. In spite of that, some EF tools were adapted and validated in some Arabic countries, not counting Lebanon; which makes it more difficult to assess EF among Lebanese children, adolescents, and adults (Roukoz et al., 2021). For that reason, we decided to select one of the pre-developed scales that are used to measure executive functions and validate it on a population within the Lebanese context, which is mainly at a private university. However, not all tests and scales cater for an evaluation of the emotional, motivational, and self-regulation aspects though they are considered as part of the EF components (Barkley & Fischer, 2011; Bueno et al., 2017; Lezak, 1982). Thus, we selected a scale that comprises all mentioned aspects of EF.

Research Question

The main question addressed in this study is whether the Lebanese validation and adaptation process of the Barkley Deficits in Executive Functions Scale – Adults version conforms to the International Test Commission (ITC) guidelines of test adaptation. This requires considering whether the adapted version has good norms and satisfactory psychometric properties (validity and reliability). For that, we generated the following research questions:

1. Does the adapted BDEFS-A show internal consistency (Cronbach alpha ≥ 0.8)?
2. Does the adapted BDEFS-A version show evidence of construct and discriminant validity?

Purpose of the Study

The purpose of this study is to validate and adapt the Barkley Deficits in Executive Functions Scale – Adults (Self-Rating scale) so that it can be used to assess the executive function deficits in adults aged 18 to 33 years at the American University of Beirut and similar populations, within the Lebanese context.

Executive functioning as a construct includes several skills/dimensions, in this study we focus on time management, organization and problem solving, inhibition, motivation, and emotion regulation.

This study aims to serve as an exploratory study that can serve as the basis for future uses of this scale in clinical applications and studies within the Lebanese community.

Our validation of the BDEFS-A scale aims to prove the accuracy and eligibility of the scale to measure the deficits in executive functions after adapting it to the target population (AUB students) in the Lebanese context. As part of the scale validation process,

we consider the relevance and existence of executive function as a universal construct with respect to our cultural context. Construct equivalence is one way to ensure that the conceptualization and measurement of the construct executive functions are similar in both groups: the originally designed for population, and the new target population (Hambleton, 2005). This process requires our attention to some influential factors that can impact the validity of the adapted version of the BDEFS-A scale, which include: evaluating the psychometric properties of the originally designed BDEFS-A scale, selecting adequate reviewers who are familiar with the construct and the culture, selecting credible judgmental, data collection, and data analysis designs for scale adaptation and equivalence confirmation (Hambleton, 2005).

Rationale Behind the Selection of the Adult Population

Executive Functions do not develop in a linear manner (Bialystok, 2011; Roukoz et al., 2021). Their development declines in adulthood (Lantrip et al., 2016; Roukoz et al., 2021); which makes it difficult to investigate the root of the problem arising from deficits in EF. However, there are adults who could be dealing with the reverberations of EF deficits without being consciously aware of their deficits (Lantrip et al., 2016). For this reason, it is important to reach out adults and assess their EFs, as it could help in quantifying any deficits found and train to remediate them.

Adults with psychological disorders, neurological impairments, and/or learning disabilities are more likely to have deficits in EF, and consequently they are more seemingly to be disadvantaged by that (Rivera et al., 2019). Deficits in EF can have a negative impact on the individual's abilities and skills including problem solving, organization and planning, time management, behavioral control and emotional regulation,

and staying attentive and motivated (Prevatt et al., 2015; Wingo et al., 2013). Thus, the impact of having deficits in EF spreads out onto the academic, professional, and social aspects of the individual's functioning (Prevatt et al., 2015; Wingo et al., 2013). As Prevatt and colleagues (2015) suggested, evaluating these areas among adults can actually serve as one way to treat or remediate the impairments in EF.

Academic Aspect (EF and Academic Success)

Based on research, it has been shown that there is an obvious influence of executive functions on adult's academic performance in college (Dehili et al., 2017; Gunzenhauser & Nückles, 2021; Rivera et al., 2019; Titz & Karbach, 2014; Wingo et al., 2013). To explain, EF can contribute to the promotion of adult's academic performance through the medium of two learning-related pathways: behavioral and cognitive (Gunzenhauser & Nückles, 2021; Rivera et al., 2019). There are some clear learning-related behaviors that are linked to some dimensions of EF which do impact the academic performance, these include sustaining attention during class, emotion regulation, and behavioral control (e.g. participate in the appropriate time rather than impulsively speaking to interrupt the instructor or colleague) (Gunzenhauser & Nückles, 2021; Rivera et al., 2019; Titz & Karbach, 2014). The learning-related cognitions can also be exemplified by taking actions that are strongly dependent on our EF, which include time management (e.g. being able to study for several quizzes that are close in dates without getting short on preparation for any of them), inhibition (e.g. being able to not attend to distracting stimuli present in class), problem solving, and attention switching (e.g. being able to shift between tasks such as reading a passage and attending to a presentation) (Gunzenhauser & Nückles, 2021; Titz & Karbach, 2014). Thus, college students who face challenges in planning, organization, time

management, inhibition… etc.; i.e. have deficits in EF, seem to experience higher levels of stress and consequently impact their learning-related behaviors and self-regulating abilities (Rivera et al., 2019; Titz & Karbach, 2014; Wingo et al., 2013). As a result, students encounter more academic-related problems which leads to poor academic performance (Rivera et al., 2019; Titz & Karbach, 2014; Wingo et al., 2013).

Professional Aspect (EF and Career)

The impact of executive functions is not confined to adult's academic success in college, it often extends to their long-term career planning and success (Barkley & Fischer, 2011; Diamond, 2013; Kern et al., 2009; Prevatt et al., 2015; Wingo et al., 2013). Adults, mainly college students, with deficits in EF; who report having problems in organization and planning, time management, and shifting attention, have been seen to have difficulty in career planning (Barkley & Fischer, 2011; Diamond, 2013; Kern et al., 2009; Prevatt et al., 2015; Wingo et al., 2013).

College students who are weak in time management find it difficult to prioritize tasks and estimate how much time the task or project will take to complete (Prevatt et al., 2015). Adding to that, deficits in EF could also be exemplified by having troubles in planning, organizing and dividing tasks, and switching attention. Having deficits in these EF skills could be carried on to the adult's professional life when they get to handle a position that requires prioritizing tasks, planning in advance for certain projects, managing time to work on multiple projects or tasks simultaneously, and being able to shift attention between the different tasks that they could be working on (Prevatt et al., 2015). It is worth noting that there is a kind of overlap between the demanding skills for academic and career

success (Prevatt et al., 2015; Wingo et al., 2013). This explains the relative influence between EF and each of academic success, and career planning/success.

Social Aspect (EF and Social Interaction)

Executive function skills are not only needed for academic and career success, but also for the individual's social life (Diamond, 2013). Social interactions often require the individual's ability to sustain attention, solve problems, and inhibit improper behaviors (Ybarra & Winkielman, 2012). Though there are different forms of social interactions, ranging from simple greetings with people you come across to going through job interviews and more formal structured social interactions (Ybarra & Winkielman, 2012). Yet, they all rely on the individuals' executive functions to different extents, with the latter demanding a higher level of EF. The mentioned requirements are much related to the executive functions (e.g. attention, behavior regulation/control, inhibition, and problem solving) in adults (Ybarra & Winkielman, 2012). Thus, adults with deficits in EF are less able to examine other's perspectives, and they're less able to sustain their attention to conversations and inhibit their behaviors and thoughts that are not aligned with the social context (Diamond, 2013; Ybarra & Winkielman, 2012). As a result, these adults often perform poorly in social contexts (Diamond, 2013; Ybarra & Winkielman, 2012).

Rationale Behind the Selection of the BDEFS

For this study, we selected the Barkley Deficits in Executive Functioning Scale – Adults (BDEFS-A) for validation and adaptation purposes as it will allow us to investigate the deficits in EF for the first time among adult population within the Lebanese context.

To ensure good psychometric properties for our validation study, we had to base it upon a standardized tool that has adequate psychometric measures when originally

constructed and published; this includes having satisfactory face validity, resulting in high level of agreement between raters (Dehili et al., 2017; Lezak, 1982). For this reason, we decided to select the Barkley Deficits in Executive Functioning Scale (BDEFS) – Adults version, which has been standardized and validated on western samples and attained satisfactory reliability measures (Cronbach alpha > 0.8 for internal consistency, and Pearson r's correlation range between 0.62 and 0.8) (Allee-Smith et al., 2013; Barkley, 2011). In addition , several sources of validity evidences (construct, discriminant, and criterion evidences) were collected to ensure that the BDEFS-A measures what it has been designed to measure; this adds on the adequacy of the scale's psychometric properties (Allee-Smith et al., 2013).

The Barkley Deficits in Executive Functioning Scale – Adults (BDEFS - A) was published by Russel Barkley in 2011. The scale was originally constructed to evaluate the deficits of EF in everyday life activities of adults, with an additional index used to screen for attention deficit hyperactivity disorder (ADHD-EF index) in adults (Dehili et al., 2017). However, it is worth noting that our focus population in this study was not limited to adults with ADHD.

BDEFS – A consists of five subscales with a total of 89 items that are scored on a four-point scale ranging from 1= never or rarely to 4= very often (Barkley, 2011). The five subscales are titled as: self-management to time, self-organization/problem solving, self-restraint, self-motivation, and self-regulation of emotions (Barkley, 2011). The subscales used in BDEFS-A include authentic items that are relevant to adult's everyday life, as they allow us to measure adults' competencies in each of time management, organization and problem solving, inhibition, motivation, and emotion regulation. Hence, the authenticity of

the items and their pertinence to adults' daily life makes it useful to make use of BDEFS-A results in individuals' career planning, as it allows the individual to highlight their EF strengths and weaknesses (Kamradt et al., 2021; Prevatt et al., 2015).

BDEFS-A subscales measure all processes involved in EF, which assures the comprehensiveness of the scale unlike other tests that are designed to measure one or two EF processes only. This drives us to another reason for selecting the BDEFS-A in particular for this study, which is the fact that it has two forms that have adequate reliability and validity: short and long. The short form takes 4-5 mins to complete, and it can be used as a brief rating scale to measure specific EF processes and/or screen for the impairment of a specific EF process (Allee-Smith et al., 2013). On the other hand, using the long scale (BDEFS-A) one can obtain a comprehensive measure of all EF processes in 15-20 mins (Allee-Smith et al., 2013). Expanding on that, the administration time of both short and long forms is considered to be attractive since it reduces the test burden for the individual being administered.

On a final note, this study required purchasing the instrument that needs to be validated (i.e. complete kit of the BDEFS-A scale); meaning that the cost of the scale should be considered too in addition to its other features. The pricing of tests developed to measure EF range from 400$ (CEFI-A) to 1043$ (D-KEFS), which is costly to purchase given the current financial situation. Thus, we selected the BDEFS-A which is more of cost-friendly than others, priced at around 144-180 depending on the source (e.g. amazon, Guilford…etc.).

Significance

This section outlines the significance of this study and the value that it will be adding.

"Executive functions are part and parcel of everything we do" (Lezak, 1982). Executive functions are important to investigate as they walk us through our positive behaviors across life (Isquith et al., 2014). They facilitate our adult living by enabling us to access different forms of information, think of solutions to the problems we face, make proper planning, and catch up with competencies that ease our independent living (Isquith et al., 2014; Lantrip et al., 2016; Lezak, 1982). The impact of having deficits in EF are under-estimated and unseen by many individuals (Lezak, 1982). Deficits in EF could impact an individual's living in several aspects. They could result in social, emotional, or behavioral complications throughout their lives (Bueno et al., 2017).

As mentioned earlier, there is a lack of studies on validations and adaptations of EF tools in Lebanon. Accordingly, there's a need to fill this gap by taking the initiative to adapt and validate a scale that is designed to measure the executive functioning among Lebanese adult population, mainly AUB students. Being more specific, the use of adult populations in our study adds on the little research done so far on similar populations in different countries since the majority of studies were based on children and adolescents. In addition to that, this study findings are expected to be useful for several types of audience, this includes adults dealing with previously mentioned problems due to deficits in EF, professionals within the fields of education and/or psychology such as psychologists, neuropsychologists, educational psychologists, and experts in assessments and tools adaptations.

The BDEFS is found to be useful in many countries (e.g. Spain, Germany) for diagnostic and interventionist purposes. Its usefulness extends onto research studies that aim to study executive functioning and are part of studies assessing neurocognitive abilities in adults. Thus, this adapted BDEFS may preamble those kinds of studies and EF-related

practices in the Arab region. Adding to that, applications of this adapted version of the BDEFS-A complement neuropsychological assessments and other self-report instruments that mainly measure the skills and traits that pertain to the executive functions (e.g. impulsivity, inhibition, behavior control, planning…etc.). Therefore, findings of this study are expected to leave impact on tailor-made psychological assessments and consequently bring up novel treatment options. From that, one can note that the availability of this adapted version in Lebanese clinics can enlarge the clinicians' set of tools available for use.

CHAPTER 2

LITERATURE REVIEW

This chapter presents a review of literature on executive functioning. Although the literature provides a wide variety of knowledge relevant to EF, this chapter focuses on some major themes that serve as a theoretical framework for the study. The following paragraphs summarize research on conceptualization and definitions of EF, its development, neuroanatomy of EF and brain regions concerned, the processes involved, its influence on different aspects of own's life and why is it that important. Then, cross-cultural similarities and differences in EF conceptualization are reviewed; followed by the assessment of EF (i.e. tools used to assess EF). Finally, the review is narrowed down to discuss how, based on literature, the instrument of focus in this study (BDEFS-A) was developed and what sort of properties it has.

Conceptualization of EF & Definitions

The concept of executive functions has been researched in a number of literature studies within the field of neuropsychology, which implies that the concept is of high importance (Baggetta & Alexander, 2016; Castellanos et al., 2018; Cristofori et al., 2019; Dehili et al., 2017; Diamond & Ling, 2016; Dores et al., 2014; Jurado & Rosselli, 2007; Kamradt et al., 2021; Lezak, 1982; Rivera et al., 2019). However, research findings have failed to produce a unified definition to this construct due to its complexity (Cristofori et al., 2019; Jurado & Rosselli, 2007; Roukoz et al., 2021).

The first appearance of executive function, as a concept, was made by Luria (1973) who considered problem solving abilities to be dependent on a number of EF skills

(planning, organization, flexibility, emotion regulation, anticipation, and error recognition) that rely on cognitive functioning, mainly frontal lobes (Cristofori et al., 2019). Another appearance was made in 1974 by Baddeley and Hitch who referred to EF as "central executive" (Cristofori et al., 2019). This concept was backed up by the case of Phineas Gage (Harlow, 1999) who suffered from a brain damage (left frontal lobes) due to the stabbing with a large iron rod; this has resulted in observed changes in his behavior and personality as being more irritable, showing less inhibition, and more hyperactivity (Cristofori et al., 2019; Goldstein et al., 2014; Ratiu & Talos, 2004). Executive functions have also been conceptualized as two-dimensional: (1) neuropsychological, which includes emotions, verbal, and/or motor behaviors (Castellanos et al., 2018; Dehili et al., 2017; Hildebrandt, 2018; Jurado & Rosselli, 2007; Lezak, 1982); and (2) neuroanatomical, which includes locating the brain regions that are associated with the neuropsychological functions of EF (Dehili et al., 2017; Dores et al., 2014; Doyle et al., 2006; Hildebrandt, 2018; Lezak, 1982).

One of the first explicit definitions to executive functions was made by Lezak (1982), noting that EFs present the 'how' dimension of our behavior; this includes our abilities to plan, form goals, carry out plans, and perform well. Later, executive functions were conceptualized as the cognitive processes that are involved in planning, organizing, and setting objectives to complete complex tasks (Ardila, 2008; Bueno et al., 2017; Cristofori et al., 2019; Dehili et al., 2017; Diamond, 2013; Doyle et al., 2006; Faria et al., 2015; Garner, 2009; Jurado & Rosselli, 2007; Kern et al., 2009; Lezak, 1982; Rivera et al., 2019). So they include a group of more complex mental abilities (including working memory, planning, sequencing, reasoning, inhibition, and problem solving) that allow us to

comprehend and process abstract ideas and enable us to handle new situations (i.e. face new challenges and properly deal with them) (Baggetta & Alexander, 2016; Cristofori et al., 2019; Diamond, 2013; Rivera et al., 2019; Titz & Karbach, 2014). Another conceptualization of executive functions was made to note that EFs rely on different metacognitive processing levels, both lower-order (e.g. memory) and higher-order ones (e.g. inhibition) (Cristofori et al., 2019; Suchy et al., 2017). To be more specific, some have conceptualized executive functions from a clinical perspective to include the ability of (1) initiation (i.e. activation of cognitive system), (2) inhibition (i.e. suppressing automatic and irrelevant responses), (3) task persistence (i.e. staying on task until completion), (4) organization, (5) cognitive flexibility (i.e. task switching and shifting), and awareness (i.e. monitoring and controlling behavior) (Boutros et al., 2020; Castellanos et al., 2018; Cristofori et al., 2019; Dehili et al., 2017; Diamond, 2013; Doyle et al., 2006; Faria et al., 2015; Jurado & Rosselli, 2007; Kamradt et al., 2021; Suchy et al., 2017; Titz & Karbach, 2014; Vélez-Pastrana et al., 2016).

Thus, despite the different conceptualizations and definitions that are similarly proposed by researchers on executive functions, there is a consensus on the fact that EFs are essential for the individual's daily living (Cristofori et al., 2019; Dehili et al., 2017; Diamond, 2013; Kamradt et al., 2021; Lantrip et al., 2016; Lezak, 1982; Meltzer et al., 2017; Rivera et al., 2019; Titz & Karbach, 2014).

Cross-cultural Research on EF

EF as a construct has been widely studied across different cultures. The interest lies in examining the similarities and differences of EF conceptualizations and measurements between different cultural contexts. Hence, cultural differences were investigated in relation

to EF measurements and performances through several studies. One of the studies was done by Lan and colleagues (2011), which reported that the individual's performances on EF tasks and battery scores were similar across both Asian (China) and American cultures (U.S). Furthermore, the association made between EF and achievement was found to be similar in some EF components (inhibition and attention) but different for the working memory which was related to prediction of reading and mathematical abilities in China, while in the United States it was found to be more related to mathematical operations (counting and calculating) than reading (Lan et al., 2011). Another study was done by Fujita and colleagues (2022), aimed to compare EF performances between Japanese and British cultures (United Kingdom - London). They reported that Japanese children outperformed the British in EF task-based assessments; which involved the assessment of inhibitory control, working memory, and cognitive flexibility (Fujita et al., 2022). However, the cultural differences were relatively small for EF performances (Fujita et al., 2022).

Thus, EF performances could be influenced by different factors, with cultural context being one of them (Ellefson et al., 2017; Fujita et al., 2022; Lan et al., 2011). It is crucial to have the construct (i.e. EF) defined and conceptualized similarly across contexts to be able to compare individual's EF performances from different cultural backgrounds.

Development of EF

Executive functions develop in an incremental manner, so they take too long to become mature (Cristofori et al., 2019; Diamond, 2013; Engelhardt et al., 2015; Goldstein & Naglieri, 2014; Jurado & Rosselli, 2007; Willoughby & Hudson, 2021). Some of the EFs start developing in infants by the age of one; though they are sensitive to stimuli so their

reactions are less controlled, yet they are able to inhibit overlearned behavior (Cristofori et al., 2019; Diamond, 2013; Engelhardt et al., 2015; Jurado & Rosselli, 2007). EFs then continue to develop during childhood, where children at the age of 10 are expected to be able to inhibit their automatic responses that are irrelevant to the task or context (Cristofori et al., 2019; Diamond, 2013; Engelhardt et al., 2015; Jurado & Rosselli, 2007). Even during adolescence, individuals continue to develop their mental abilities that are involved in inhibition, working memory, decision making and processing speed (Castellanos et al., 2018; Cristofori et al., 2019; Diamond, 2013; Lantrip et al., 2016). The difference between children and adults with regards to their executive functioning is that children opt to use their EFs to reactively respond to environmental stimuli while adults use their EFs in a more planned and conscious way (Castellanos et al., 2018; Diamond, 2013).

Executive functions continue to develop and improve with time, at different paces and levels among children and adolescents; this could be influenced by genetics, environment, and other developmental factors (Brown, 2006; Cristofori et al., 2019; Diamond, 2013; Engelhardt et al., 2015). Adding to that, the different processes involved in EF develop at different times. For instance, inhibition is a complicated process for young children, so it develops more noticeably in older children (9y+) and continues to maturate during adolescence (Diamond, 2013; Jurado & Rosselli, 2007). Yet, it declines with aging so that older adults perform poorer at suppressing distractions while performing a task, than younger adults (Diamond, 2013; Jurado & Rosselli, 2007; Princiotta et al., 2014). Similarly, the working memory declines with aging; however, the development of working memory starts at an earlier age than inhibition and at a faster pace where infants and young children seem to be capable of handling more than one thing in mind for a significant period of time

(Diamond, 2013; Princiotta et al., 2014). On the other hand, cognitive flexibility takes more time to develop, when compared to the working memory and inhibitory control (Diamond, 2013).

The development of EFs during adolescence and adulthood is non-linear, where young adults and adolescents show better performance on EFs tasks than older adults (Cristofori et al., 2019; Diamond, 2013; Jurado & Rosselli, 2007; Roukoz et al., 2021; Vélez-Pastrana et al., 2016). This could be due to the aging effect on the brain anatomy where there appears to be a volume reduction and decline in the neural organization of the brain that is associated with the EFs, which begins by mid-adulthood (Ardila, 2008; Barkley, 2001; Bialystok, 2011; Boutros et al., 2020; Cristofori et al., 2019; Doyle et al., 2006; Jurado & Rosselli, 2007; McGrath et al., 2021; Princiotta et al., 2014).

Thus, research has shown that there is a correlation between aging and the drop in performance of EFs; which could explain the reason behind having older adults performing poorer on EF tasks than children and young adults (Ardila, 2008; Barkley, 2001; Bialystok, 2011; Boutros et al., 2020; Cristofori et al., 2019; Elderkin-Thompson et al., 2008; Faria et al., 2015; Jurado & Rosselli, 2007; McGrath et al., 2021; Princiotta et al., 2014).

Neuroanatomy of EF (Relation to Cognition)

Neuroimaging of the brain has indicated that the prefrontal cortex (PFC) is the most associated region with executive functions (EF) (Ardila, 2008; Cristofori et al., 2019; Diamond, 2013; Doyle et al., 2006; Lezak, 1982; Lyvers et al., 2014; Welsh & Peterson, 2014). The PFC is divided into three parts: medial, dorsolateral, and orbitofrontal; it makes up almost 30% of the full complement of the cortical cells (Ardila, 2008; Boutros et al., 2020; Cristofori et al., 2019; Doyle et al., 2006; Elderkin-Thompson et al., 2008; Jurado &

Rosselli, 2007; Meltzer et al., 2017; Welsh & Peterson, 2014). It is highly sensitive to brain injuries, due to its location and position. Thus, individuals with a damaged PFC due to brain injury often have deficits in EFs (Barkley, 2001; Cristofori et al., 2019; Dores et al., 2014; Willoughby & Hudson, 2021). At times, large injuries in PFC might yield to dysexecutive syndrome, which is mainly associated with serious deficits in EFs affecting the individual's cognitive abilities, inhibition, planning, emotion control, social and goal-oriented behavior (Ardila, 2008; Barkley & Fischer, 2011; Bueno et al., 2017; Cristofori et al., 2019; Dehili et al., 2017; Diamond, 2013; Dores et al., 2014; Goldstein & Naglieri, 2014).

Although executive functions are highly reliant on the prefrontal cortex (PFC), there are other cortical (e.g. parietal cortex) and subcortical (e.g. working memory like anterior corona radiata) brain regions that can make up for the correction of the impaired executive functions (Ardila, 2008; Cristofori et al., 2019; Diamond, 2013; Goldstein & Naglieri, 2014; Hofmann et al., 2012; Isquith et al., 2014; Jurado & Rosselli, 2007). However, in some cases, deficits in EFs are caused by brain injuries directly affecting one (or more) of the cortical/subcortical regions that will indirectly influence the PFC region, which is mainly associated with the EFs (Cristofori et al., 2019; Diamond, 2013; Dores et al., 2014; Jurado & Rosselli, 2007; Sudikoff et al., 2015; Welsh & Peterson, 2014; Willoughby & Hudson, 2021).

Processes Involved in EF

The concept of executive functions encompasses multiple processes, it includes working memory, cognitive flexibility, organization and problem solving, reasoning, planning, time management, inhibition, motivation, and emotion regulation (Barkley, 2001;

Diamond, 2013; Dohle et al., 2018; Doyle et al., 2006; Kern et al., 2009; Lyvers et al., 2014; Packwood et al., 2011; Suchy et al., 2017; Titz & Karbach, 2014). EFs deficits could influence one or more of the mentioned processes, consequently impacting the individual's ability to work, study, and/or pursue daily activities (Allee-Smith et al., 2013; Bueno et al., 2017; Cristofori et al., 2019; Diamond, 2013; Kamradt et al., 2021; Lantrip et al., 2016; Meltzer et al., 2017; Titz & Karbach, 2014).

Working Memory

One of the main cognitive processes involved in executive functioning is the working memory (WM). Different models contribute to the understanding of the working memory. Some claim that it represents a flexible system with a restricted capacity that divides available resources into storage and processing, while others perceive WM as (1) part of the long-term memory that is activated by specific attentional resources, or as (2) the summation of the short-term memory and attention (Faria et al., 2015; Titz & Karbach, 2014; Ybarra & Winkielman, 2012).

Working memory (WM) allows the individual to keep the information available (i.e. remember the information) while carrying out other cognitive tasks (e.g. note taking in a lecture) (Baggetta & Alexander, 2016; Bialystok, 2011; Castellanos et al., 2018; Cragg et al., 2017; Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016; Dohle et al., 2018; Doyle et al., 2006; Faria et al., 2015; Garner, 2009; Gunzenhauser & Nückles, 2021; Hofmann et al., 2012; Jurado & Rosselli, 2007; Roukoz et al., 2021; Titz & Karbach, 2014; Ybarra & Winkielman, 2012). WM also enables us to make connections between our different sources of knowledge, and this gets us to make sense of the bits and pieces that we come across in which we can connect it to the bigger image of our knowledge (Baggetta &

Alexander, 2016; Cragg et al., 2017; Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016; Dohle et al., 2018; Doyle et al., 2006; Faria et al., 2015; Garner, 2009; Gunzenhauser & Nückles, 2021; Hofmann et al., 2012; Jurado & Rosselli, 2007; Roukoz et al., 2021; Titz & Karbach, 2014; Ybarra & Winkielman, 2012). Hence, it contributes to our conceptualization of knowledge (Diamond, 2013).

The performance of the working memory is dependent on the status of the lateral prefrontal cortex, where a normal performance would require having an unimpaired PFC (Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016; Doyle et al., 2006; Elderkin-Thompson et al., 2008; Lyvers et al., 2014). This is especially the case when there is an increase in the cognitive task difficulty (Cristofori et al., 2019; Wingo et al., 2013). Adding to that, a normal functioning of working memory requires having a normal orbitofrontal cortex structure which is responsible for the maintenance, manipulation, and monitoring of processes involved in the working memory (Cristofori et al., 2019; Diamond, 2013; Garner, 2009; Goldstein & Naglieri, 2014).

Cognitive Flexibility

Cognitive flexibility is another process involved in human's executive functions. It enables the individual to adapt to environmental and situational changes (Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016; Roukoz et al., 2021). It is also responsible for the individual's ability to produce novel ideas that would contribute to their growth and exploration (Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016; Roukoz et al., 2021). It allows us to view things from multiple perspectives; this demands inhibiting previous perceptions and activating new ones from a different perspective (Allee-Smith et al., 2013; Diamond, 2013; Diamond & Ling, 2016; Garner, 2009). This implies that it

counts on both processes: working memory and inhibition (Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016).

Cognitive flexibility is much reliant on the functioning of different prefrontal areas, including the frontoparietal regions (Ardila, 2008; Cristofori et al., 2019; Diamond, 2013; Doyle et al., 2006). This implies that brain injuries impairing the PFC can lead to deficits in cognitive flexibility and consequently affect the ability to shift attention and switch between tasks (Barkley, 2001; Cristofori et al., 2019; Diamond, 2013; Dores et al., 2014; Willoughby & Hudson, 2021).

Organization and Problem Solving

Executive functions encompass the process of organization and problem solving. This includes the ability to face challenges and find solutions to problems arising, which fosters the individual's critical thinking (Allee-Smith et al., 2013; Bolden & Fillauer, 2020; Cristofori et al., 2019; Doyle et al., 2006; Ybarra & Winkielman, 2012). Similar to previous processes, problem solving is also influenced by the prefrontal cortex structure (Ardila, 2008; Bolden & Fillauer, 2020; Cristofori et al., 2019; Ybarra & Winkielman, 2012). Thus, deficits in problem solving are associated with impairments in PFC (Ardila, 2008; Bolden & Fillauer, 2020; Cristofori et al., 2019).

Reasoning

When speaking of executive functions, one shall come across the reasoning abilities in individuals. Reasoning serves as the essence of making generalizations and understanding of abstract concepts; it promotes the individual's ability to build concepts and be creative (Cragg et al., 2017; Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016; Elderkin-Thompson et al., 2008). Thus it requires an activation of the working

memory, being selectively attentive to what is considered relevant and suppressing distractions that are not relevant to the context (i.e. inhibitory control) (Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016).

Planning and Time-Management

Planning and time-management serve as two of the main higher-order cognitive processes involved in EF. They are associated with goal-oriented behaviors, as they include the ability to organize time properly, as well as devise, evaluate, and properly select actions that are essential to accomplish a goal (Ardila, 2008; Bueno et al., 2017; Cristofori et al., 2019; Doyle et al., 2006; Faria et al., 2015; Garner, 2009; Jurado & Rosselli, 2007; Lezak, 1982; Roukoz et al., 2021; Vélez-Pastrana et al., 2016). Time-management skills seem to be adequate when the individuals are capable of (Allee-Smith et al., 2013; Bolden & Fillauer, 2020; Vélez-Pastrana et al., 2016): (1) planning out their time to meet deadlines, (2) focusing on what is important and avoiding what is not, (3) handling multiple tasks and prioritizing them, (4) accomplishing what they have planned out in mind, (5) remaining on task until completion, (6) respecting deadlines and organizing their work to not miss any. On the other hand, deficits in planning and time-management can negatively impact other EF processes such as cognitive flexibility (i.e. switching), generalizing, and judging the adequacy and usefulness of a plan (Ardila, 2008; Bueno et al., 2017; Cristofori et al., 2019; Doyle et al., 2006; Faria et al., 2015; Garner, 2009; Jurado & Rosselli, 2007; Lezak, 1982; Roukoz et al., 2021; Vélez-Pastrana et al., 2016).

Inhibition

The inhibition process involved in EF is connected to the working memory and strongly related to the one’s ability to monitor behavior. Inhibition comprises the ability to

suppress automatic responses that are irrelevant to the situation (i.e. inhibition in action) and the ability to withhold memory restoration of irrelevant information (i.e. inhibition in attention) (Bialystok, 2011; Cristofori et al., 2019; Diamond, 2013; Doyle et al., 2006; Elderkin-Thompson et al., 2008; Hofmann et al., 2012; Ybarra & Winkielman, 2012).

Inhibitory control is what allows us to overcome our past thoughts, act in an impulsive way, and choose how to react to stimuli (Bueno et al., 2017; Diamond, 2013; Doyle et al., 2006; Engelhardt et al., 2015; Hofmann et al., 2012; Jurado & Rosselli, 2007). It impacts our ability to remain on task when presented with distractions, hence combatting temptations and suppressing our impulsivity (i.e. automatic reactions) (Diamond, 2013; Diamond & Ling, 2016).

Inhibitory control is also related to self-control and regulation, as it keeps us alert of our reactions, thinking, and behavior; it also enables us to be selectively attentive by focusing on what we choose to attend to and inhibit our attention to what we consider irrelevant (Bolden & Fillauer, 2020; Diamond, 2013; Dohle et al., 2018; Garner, 2009; Hildebrandt, 2018; Hofmann et al., 2012; Sudikoff et al., 2015; Vélez-Pastrana et al., 2016; Welsh & Peterson, 2014).

The prefrontal cortex (PFC) is the main root of inhibitory control, meaning that it is more associated with the inhibition processing (action and attention) compared to other brain regions (Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016). Individuals with a normal functioning PFC are able to control their thoughts and actions, so they would control their impulsivity and suppress their inappropriate thoughts or actions (Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016).

Emotion and Self-Regulation

Self-regulation and emotion control are part of the executive function processes. The regulation refers to the ability to control one's emotions, thoughts, and behaviors (Barkley, 2001; Bolden & Fillauer, 2020; Diamond, 2013; Dohle et al., 2018; Garner, 2009; Hofmann et al., 2012; Lyvers et al., 2014; Titz & Karbach, 2014); which is influenced by the individual's level of motivation and interest to control their emotions and monitor their thoughts and actions (Ardila, 2008; Bolden & Fillauer, 2020; Diamond, 2013; Dohle et al., 2018; Garner, 2009; Vélez-Pastrana et al., 2016). This grants us an optimum activation of emotional, motivational, and cognitive levels (Ardila, 2008; Diamond, 2013; Dohle et al., 2018; Garner, 2009; Vélez-Pastrana et al., 2016).

This requires the individual's ability to be aware of them in the first place, prior to controlling and regulating them (Hildebrandt, 2018; Lyvers et al., 2014; Titz & Karbach, 2014); which relates back to the individual's inhibitory control (Baggetta & Alexander, 2016; Cragg et al., 2017; Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016; Hofmann et al., 2012; Suchy et al., 2017; Vélez-Pastrana et al., 2016; Welsh & Peterson, 2014). To do so, individuals are encouraged to reflect on their contextual thoughts and actions that they take in certain situations, since this results in having controlled attention and cognitive flexibility, which are vital for executive functioning (Castellanos et al., 2018; Titz & Karbach, 2014; Welsh & Peterson, 2014).

On another note, neuroimaging has shown that there is an arousal of the ventral prefrontal cortex, which is linked to the temporal lobe including hypothalamus and amygdala, during self and emotional regulation (Cristofori et al., 2019; Lantrip et al., 2016; Lyvers et al., 2014). The ventral prefrontal cortex matures with age, so adults tend to have

more efficient prefrontal cortical functioning compared to younger individuals; which explains their more effective emotion and self-regulation (Lantrip et al., 2016; Sudikoff et al., 2015). Adding on that, studies imply that there are gender differences in amygdala functioning so that females are shown to have more effective emotional regulation during adolescence (Goldstein & Naglieri, 2014).

How are the EF Processes Related?

As previously discussed, the concept of executive function encompasses multiple processes. The processes involved in EF are all related in one way or another. To explain, the processing of working memory involves the activation of inhibitory control and cognitive flexibility, which altogether allow for switching between tasks, selective attention, and multitasking (Baggetta & Alexander, 2016; Dehili et al., 2017; Diamond, 2013; Garner, 2009; Goldstein et al., 2014; Gunzenhauser & Nückles, 2021; Hildebrandt, 2018; Isquith et al., 2014; Princiotta et al., 2014; Welsh & Peterson, 2014; Willoughby & Hudson, 2021). In fact, working memory and inhibitory control support one another (Diamond, 2013). This is evident in situations where an individual has to relate different ideas, and switch between tasks while attending to what is relevant to the context, and inhibiting attention to distractors (Diamond, 2013). Adding to that, working memory and inhibitory control are dependent on the activation of the same brain regions so an increasing use of one process will technically impact the individual's ability to process the other (Cristofori et al., 2019; Diamond, 2013; Diamond & Ling, 2016; Doyle et al., 2006; Elderkin-Thompson et al., 2008; Lyvers et al., 2014). This implies that they both demand a normal structuring and functioning of the prefrontal cortex (Cristofori et al., 2019;

Diamond, 2013; Diamond & Ling, 2016; Doyle et al., 2006; Elderkin-Thompson et al., 2008; Lyvers et al., 2014).

After all, there is an obvious relation between each of working memory, inhibitory control, and cognitive flexibility. Cognitive flexibility is highly correlated with the ability to switch between tasks, and creativity (Baggetta & Alexander, 2016; Boutros et al., 2020; Diamond, 2013; Faria et al., 2015; Lezak, 1982; Pichler, 1983; Willoughby & Hudson, 2021). Thus, the development of cognitive flexibility in individuals requires their pre-development of each of working memory and inhibition (Diamond, 2013).

Importance of EF on Different Aspects

Literature shows that there is significant research being done on the importance of EF in a variety of domains and aspects (Dehili et al., 2017; Diamond, 2013). Studies propose that the importance of EF extends to every aspect of life as they allow for the development of skills that are useful in everyday life, with special regards given to academic, professional, and social life (Dehili et al., 2017; Diamond, 2013).

Academic Aspect

Studies have shown that there is an association between the individual's EF and their academic performance; whereby individuals with well-developed EFs portray a better academic performance than those with EF deficits (Dehili et al., 2017; Gunzenhauser & Nückles, 2021; Rivera et al., 2019; Titz & Karbach, 2014; Wingo et al., 2013). EFs promote academic performance through two routes named as (1) learning-associated behaviors; and (2) learning-associated cognitions (Gunzenhauser & Nückles, 2021; Rivera et al., 2019).

Learning-associated behaviors include being able to remain on task until completion while avoiding distractions, whereas learning-associated cognitions involve selecting information only relevant to the learning context and sustaining attention to remember and follow instructions (Gunzenhauser & Nückles, 2021). Furthermore, there are some learning-related behaviors that are found to play a huge role in one's academic success. These behaviors are directly influenced by some EF processes, such as sustaining attention, regulating emotions and maintaining self-motivation, and behavior control (e.g. suppressing the urge to impulsively react to an opposing point of view shared by a colleague) (Gunzenhauser & Nückles, 2021; Rivera et al., 2019; Titz & Karbach, 2014). Of equal importance, there are some learning-related cognitions that are dependent on certain EF processes and are found to impact one's academic performance. These include time management and organization (e.g. setting a plan to organize and prioritize tasks to meet their deadlines), inhibitory control (e.g. disregard the presence of a distractor and inhibiting the need to attend to it), problem solving, and set-shifting (e.g. shifting between tasks while sustaining attention such as presenting in front of others and attending to their questions to answer) (Gunzenhauser & Nückles, 2021; Titz & Karbach, 2014).

Thus, individuals who have deficits in EF are at a higher risk of having poor self-regulating abilities and inadequate learning-related behaviors. They seem to face challenges with time management, planning, and organization to deal with multiple tasks (e.g. meeting several deadlines close in time); consequently, this influences their self-motivation and distracts them from being able to self-regulate their emotions and behavior to handle an independent and purposeful college/academic life (Rivera et al., 2019; Titz & Karbach, 2014; Wingo et al., 2013). This results in more academic-related problems that individuals

with EF deficits fail to solve on their own, and they might find it difficult to seek help from others; which then results in their poor academic performance (Rivera et al., 2019; Titz & Karbach, 2014; Wingo et al., 2013).

Professional Aspect

Noting that the focus of this study is on adults' population, we considered reviewing literature to examine the significance of EF on the individual's career planning and success. Research has shown that EF can have a significant impact on adults' long-term career planning and success (Barkley & Fischer, 2011; Diamond, 2013; Kern et al., 2009; Prevatt et al., 2015; Wingo et al., 2013). Hence, adults with deficits in EF face difficulties in organization and planning, time management, and shifting attention which directly influence their ability to carry out career plans and handle positions that rely on EF processes (Barkley & Fischer, 2011; Diamond, 2013; Kern et al., 2009; Prevatt et al., 2015; Wingo et al., 2013). This could be sensible for adults who get placed in positions that rely on their abilities to prioritize tasks and planning ahead of time, generate solutions to problems encountered at work, sustaining their attention to get the task completed despite the presence of distractors, and shifting abilities between tasks (Prevatt et al., 2015).

Thus, career options can be enhanced or limited by adults' EF abilities. Therefore, assessing their EF will allow adults to be aware of their strengths and weaknesses in EF-based tasks or conditions (Prevatt et al., 2015; Wingo et al., 2013).

Personal and Social Aspect

EFs are found to be influential on personal and social aspects of the individual's life (Diamond, 2013). Individuals with well-developed EFs are shown to have a better quality of life, whereas those with EF deficits tend to be more stressed as they find it difficult to

deal with life challenges (Rivera et al., 2019). Knowing that stress negatively influences one's mental health, then one can claim that individuals with EF deficits are more probable to have poor mental health (Diamond, 2013).

EFs can even impact the adult's marital life, since those with poor EFs tend to be more impulsive due to their poor inhibitory control and they are more difficult to get along with; which could cause them more problems with their partners (Goldstein & Naglieri, 2014). Adding on that, social relationships in general rely on the individual's competencies in sustaining attention, appropriately dealing with problems, and suppressing inappropriate behaviors (Ybarra & Winkielman, 2012).

Expanding on what has been previously mentioned, social interactions differ across situations, so they vary in the extent through which they rely on EF processes. For instance, formal structured social interactions like job interviews demand a higher degree of EF processes (e.g. attention, inhibition of inappropriate and irrelevant responses, self-regulation…etc.) than informal social interactions like communicating with friends or siblings (Ybarra & Winkielman, 2012). Thus, EFs are useful in individual's personal and social aspects of everyday life which demand different degrees of EF processes (Diamond, 2013; Ybarra & Winkielman, 2012).

Assessing Executive Functions

There have been several tools developed to measure executive functions across several age groups; young children up till old adults (Ardila, 2008; Castellanos et al., 2018; Cragg et al., 2017; Cristofori et al., 2019; Dehili et al., 2017; Doyle et al., 2006; Elderkin-Thompson et al., 2008; Faria et al., 2015; Lezak, 1982; McCloskey et al., 2009; Meltzer et al., 2017; Roukoz et al., 2021; Suchy et al., 2017; Ybarra & Winkielman, 2012). The tools

include standardized tests, cognitive tasks, observations, work samples, and interviews (Cristofori et al., 2019). Some tools are designed to assess specific components or processes that are involved in EFs, while others are more comprehensive. To obtain reliable measures, data should be collected using multiple sources so more than one tool would be in use (Cristofori et al., 2019). Hence, qualitative data could be obtained from individual's work samples, interviews, and observations; these could be used to serve study purposes that aim to look through the quality of executive functioning in specific individuals. On the other side, standardized tests and cognitive tasks are seen to be more practically used in concrete contexts as they allow for quantifying the individual's deficits and abilities and looking through the severity of deficits found.

Tests Used to Assess EF in General

In general, standardized tests are more frequently used, or relied on, than other tools as they allow professionals (i.e. clinicians, researchers, and neuropsychologists) to better quantify the individual's EF capabilities and deficits. Among the most commonly used tests for the assessment of specific EF processes, there's (1) the Wisconsin Card Sorting Test (WCST) which focuses on learning and shifting of rules; (2) the Trail Making – part B which assesses the ability of shifting as well; (3) the Stroop Color Word Interference Test which assesses the ability to inhibit irrelevant info; and (4) the Tower of Hanoi and London (TOH and TOL) which assess planning (Ardila, 2008; Barkley, 2001; Barkley & Fischer, 2011; Brown, 2006; Cristofori et al., 2019; Diamond & Ling, 2016; Faria et al., 2015; Goldstein & Naglieri, 2014; McCloskey et al., 2009; Packwood et al., 2011; Princiotta et al., 2014; Roukoz et al., 2021; Titz & Karbach, 2014; Wingo et al., 2013).

As for the comprehensive assessment of EFs, the most commonly used are Delis-Kaplan Executive Function System (D-KEFS) and the Behavioral Assessment of Dysexecutive Syndrome (BADS) (Bueno et al., 2017; Cristofori et al., 2019; Faria et al., 2015; Hildebrandt, 2018; Jurado & Rosselli, 2007; Suchy et al., 2017; Wingo et al., 2013).

There are other tests that are used to assess specific components of executive functions, which could be used along with other tests to come up with a full assessment of an individual's executive functions. For instance, tests that assess the inhibition component include (Boutros et al., 2020; Cristofori et al., 2019; Faria et al., 2015; Hildebrandt, 2018; Jurado & Rosselli, 2007; Lyvers et al., 2014): (1) Brixton Spatial Anticipation Test; (2) Cambridge Neurological Inventory; (3) Frontal Systems Behavior Scale; (4) Hayling Sentence Completion test; (5) Stroop Test; (6) Sustained Attention to Response Task. For the task switching or set shifting component, tests include (Baggetta & Alexander, 2016; Cristofori et al., 2019; Faria et al., 2015; Wingo et al., 2013): (1) Design Fluency Test; (2) Wisconsin Card Sorting Test (WCST). To assess the processing of working memory, one can use the Greenwich Test (Cristofori et al., 2019). As for the assessment of planning, multiple tests are useful to consider and they include: (1) Greenwich Test; (2) Multiple Errands Test; (3) Six Elements Test; (4) Tower of Hanoi; (5) Tower of London (Ardila, 2008; Barkley, 2001; Barkley & Fischer, 2011; Brown, 2006; Cristofori et al., 2019; Goldstein & Naglieri, 2014; Jurado & Rosselli, 2007; Packwood et al., 2011; Princiotta et al., 2014; Titz & Karbach, 2014; Willoughby & Hudson, 2021). Adding on, the initiation component of EF is commonly assessed by (Cristofori et al., 2019; Lyvers et al., 2014): (1) Cambridge Neurological Inventory; and (2) Frontal Systems Behavior Scale. Finally, the sequencing and decision making can each be assessed by Cambridge Neurological

Inventory for the first, and Iowa Gambling Test for the latter (Cristofori et al., 2019; Goldstein & Naglieri, 2014; Suchy et al., 2017; Welsh & Peterson, 2014).

Tools Used to Assess EF in Adults

Some tests developed to assess executive functions are only applicable on specific populations; meaning that they might not be of use for adults (Suchy et al., 2017). Thus, some professionals resort to specific tasks that adults can engage in and make use of their task performance as an indication of their EF skills; this includes the n-back task, go/no-go task, and/or the Rapid Search Visual Presentation (RSVP) task (Dehili et al., 2017; Isquith et al., 2014; Rivera et al., 2019; Suchy et al., 2017). The n-back task is performance task that allows for the measurement of the individual's working memory by having them call back a set of items in a specific order and decide whether the presented stimulus matches the item presented "n" standpoints before (Jaeggi et al., 2010). The go/no-go task is a responsive based task that aims to measure the inhibitory control of individuals by having them respond automatically when presented with "go" stimulus by pressing on a button, and inhibiting their response when presented with the "no-go" stimulus (Isquith et al., 2014). The RSVP is a task that allows for the measurement of attention deficits of participants while requiring them to remain attentive and select the item (target) that differentiates from the remaining stream of stimuli at a speedy rate (Dehili et al., 2017; Isquith et al., 2014). These tasks could be used alongside with some tests/scales developed to measure specific EF components in adults, such as (1) Trail Making Test - Form B (cognitive flexibility), (2) Clock Drawing Test (planning), (3) Digits Forward and Backward subtests (WAIS-R or WAIS-III) (working memory), (4) Stroop Test (inhibitory

control), and (5) Wisconsin Card Sorting Test (WCST) (cognitive flexibility) (Faria et al., 2015).

In addition to previously mentioned EF testing tools, adults' skills could also be measured using specific versions of comprehensive scales. The scales include (1) Behavior Rating Inventory of Executive Function-Adults (BRIEF-A), (2) Delis-Kaplan Executive Function System (D-KEFS), (3) Barkley Deficits in Executive Functioning Scale-Adults (BDEFS-A), (4) Dysexecutive Questionnaire (DEX), (5) Executive Function Index (EFI), (6) Brown Executive Functions/Attention Scale (Brown EF/A scale), and (7) Comprehensive Executive Functions Inventory-Adults (CEFI-A) (Brown, 2019; Garner, 2009; Goldstein & Naglieri, 2014; Prevatt et al., 2015; Wingo et al., 2013).

This paragraph will present a summary of each of the previously mentioned comprehensive rating scales used to assess EF in adults. First, BRIEF-A consists of nine subscales that include a total of 75 items related to inhibition, set shifting, emotion regulation, self-regulation, initiation, working memory, planning, task completion, and material organization (Wingo et al., 2013). Second, D-KEFS consists of nine subscales that measure verbal and non-verbal EF skills, named as Trail Making, Verbal Fluency, Design Fluency, Color-Word Interference, Card Sorting, Twenty Questions, Word Context, Tower, and Proverbs (Wingo et al., 2013). Third, BDEFS-A aims to assess impairments in executive functions and consists of five subscales with a total of 89 items related to time management, organization/problem solving, inhibition, motivation, and self-regulation (Prevatt et al., 2015). Fourth, DEX is a comprehensive tool used to measure executive functions deficits and their impact on everyday life (Goldstein & Naglieri, 2014). Fifth, EFI consists of five subscales that allow for the measurement of EF in adults, with a total of 27

items related to: inhibition, planning, motivation, organization, and empathy (Garner, 2009). Sixth, Brown EF/A scale allows for screening of ADHD and EF deficits as it includes around 56-58 items that relate to organization, set shifting, emotion-regulation, working memory, self-regulation, and alertness/attention (Brown, 2019). Finally, CEFI is a comprehensive inventory that assesses executive functions with a total of 100 items that relate to the nine subscales: attention, emotion regulation, flexibility, inhibitory control, initiation, organization, planning, self-monitoring, and working memory (Goldstein & Naglieri, 2014).

Development of BDEFS – A

Each of the tests designed to assess EFs has certain limitations; this includes focusing on the measurement of one of the EF components only, lack of relation between test items and adult's everyday life, and the absence of multiple forms and versions that allow for assessing of EF in individuals from different perspectives (Allee-Smith et al., 2013). In response to these limitations, Barkley developed the BDEFS-A as a comprehensive scale that assesses impairments of all EF processes in place of specific EF cognitive processes (Allee-Smith et al., 2013; Kamradt et al., 2021; Prevatt et al., 2015). Furthermore, Barkley aimed to develop the BDEFS-A with subscales that are strongly associated with the cognitive processes involved in adult's independent life activities; e.g. time management, inhibition, self-motivation…etc. (Allee-Smith et al., 2013; Kamradt et al., 2021); which makes the BDEFS-A measures of EF useful for career planning for young adults (i.e. college students) (Kamradt et al., 2021; Prevatt et al., 2015).

BDEFS-A has emerged as an empirical EF tool with adequate psychometric properties; alpha coefficient measures greater than 0.91 (reliability), and some evidences of

validity (construct, discriminant, and criterion related) (Allee-Smith et al., 2013; Dehili et al., 2017; Kamradt et al., 2021; Vélez-Pastrana et al., 2016); which are discussed in more detail in below psychometric properties section. BDEFS-A has outperformed previous EF tests in terms of time, costs, and predictive abilities of EF impairments' impact in daily life activities (Allee-Smith et al., 2013). Adding on what has been previously mentioned, unlike other EF tests, BDEFS-A features an ADHD-EF index that allows for the prediction of ADHD in adults; which has also been supported by multiple forms of analyses that strengthen the validity and reliability measures of the tool (Allee-Smith et al., 2013; Dehili et al., 2017; Kamradt et al., 2021; Prevatt et al., 2015; Vélez-Pastrana et al., 2016).

Normative Sample

BDEFS-A was constructed with a normative sample of 1,249 adults with an age range of 18 to 96 years (Allee-Smith et al., 2013). The sample is representative based on 2000 U.S. Census data with regards to gender, educational background, race, socioeconomic status, employment status, marital status, and geographical distribution (Allee-Smith et al., 2013).

Administration and Scoring

BDEFS is an individually administered tool that can be used in clinical, research, and occupational settings to identify those with EF impairments (Allee-Smith et al., 2013). Administration of BDEFS should only be done by an experienced professional who has received training in the field of psychology, while scoring and interpreting the results can be done by a professional who has completed graduate-level training in the field of psychological measurement (Allee-Smith et al., 2013; Barkley, 2011).

BDEFS-A consists of three versions: self-report, other-report, and clinical interview. The self-report investigates the extent through which individuals have showed certain behaviors for the last six months, and it should be filled out by the adult (Allee-Smith et al., 2013; Barkley, 2011). The other-report shares the same items and purpose as the self-report version, however it is filled out by a significant other (i.e. sibling, spouse, parent) who knows the adult enough to be able to provide accurate info about their daily functioning (Allee-Smith et al., 2013; Barkley, 2011). Completion of the other-report version is not required but it can be used to ensure reliability and evaluate the validity of the individual's responses (Allee-Smith et al., 2013; Barkley, 2011). The items on both self-report and other-report versions are measured on a 4-point Likert scale: (1) Never or rarely; (2) sometimes; (3) often; (4) very often. The clinical interview is used in case the adult is unable to complete the rating scale independently by asking yes/no questions and to what extent (often or very often) certain behaviors had shown up over the last 6 months (Allee-Smith et al., 2013; Barkley, 2011).

BDEFS-A includes two versions of rating scales for each of self-report and other-report: long form (LF) and short form (SF). The long form consists of 89 items and takes 15-20 mins to complete, while the short form includes only 20 items and takes 4-5 mins (Allee-Smith et al., 2013; Barkley, 2011).

The *long form* is scored by tallying the scores obtained in each subscale and adding them to find their sum which represents the total score (Allee-Smith et al., 2013). Adding on that, items receiving 3 or 4 points (often or very often) can be tallied to indicate a symptom count of executive functioning (Allee-Smith et al., 2013). Then, raw scores are converted into percentile ranks using the appropriate scoring sheet (based on appropriate

age and gender). Scoring of long form is the same for both self-report and other-report versions, however the percentile ranks and norms are only convenient for the self-report version (Allee-Smith et al., 2013).

The *short form* is scored in a similar manner as the long form (Allee-Smith et al., 2013). However, the norms are only available for the short form self-report version (age only), while the other-report version does not have any norms (similar to long form) (Allee-Smith et al., 2013).

The *clinical interview* is scored by counting the number of "yes" responses provided on the form, as they result with a total EF symptom count (Allee-Smith et al., 2013). This form does not have norms, but it highly correlates with the short form self-report version (0.90+), so the ranking can be indicated by referring to the short-form self-report version (by age) (Allee-Smith et al., 2013).

Psychometric Properties

The psychometric properties (i.e. reliability and validity) of BDEFS-A were thoroughly assessed in a series of reliability and validity studies.

Reliability of BDEFS-A. Reliability indicates the precision and consistency measures of the testing instrument, through which it yields to similar scores at different attempts (Fitzner, 2007; Roberts et al., 2006). The reliability measures of BDEFS-A were obtained from internal consistency and test re-test measures, which were found to be quite satisfactory.

Internal Consistency of BDEFS-A. Internal consistency refers to the extent to which test items yield to consistent results within the test itself (Fitzner, 2007). The internal consistency was measured using Cronbach's alpha ($\boldsymbol{\alpha}$) and Pearson's product-moment

correlation (r). Cronbach's alpha was reported for the self-report BDEFS-LF (long forms) as a range from 0.91 to 0.96 on all subscales, and 0.92 for the self-report BDEFS-SF (short forms), while no measures were reported for the other-report version (Allee-Smith et al., 2013; Barkley, 2011). Pearson's r correlations ranged between 0.55 and 0.80 across the different subscales, however the different versions of BDEFS were highly correlated (Allee-Smith et al., 2013; Barkley, 2011).

Test-retest Reliability of BDEFS-A. Test-retest reliability refers to the ability of test to produce same results over a period of time (Fitzner, 2007). Test re-test measures were obtained from a randomized selection of 62 participants from the normative sample, who were asked to complete the same self-report form (2nd time) after 2-3 weeks. The scores obtained on the 2nd completion were then compared with the original scores (1st completion), which showed significant correlating measures with an r ranging from 0.62 to 0.80 and p-value <0.001.

Validity of BDEFS-A. Validity indicates the accuracy of tool measuring what it is designed to measure (Fitzner, 2007; Roberts et al., 2006). Validity measures of BDEFS-A were based on construct, discriminant, and criterion validity evidence.

Construct Validity of BDEFS-A. Construct validity refers to the degree of alignment between the construct (i.e. its theoretical conceptualization) and the instrument being used to measure the construct (Fitzner, 2007). For the construct validity, Barkley's definition of executive functions was used and accordingly subscales of the BDEFS-A were tested to see if they correlate with other EF tests. Thus, two instruments were used for convergent validity (Barkley, 2011): (1) Conners Continuous Performance Test (Conners CPT); and (2) Stroop Color-Word Test. The correlation between BDEFS and Conners CPT

ranged between 0.04 and 0.41, which is considered as weak-moderate (Barkley, 2011); while the correlation between BDEFS and the Stroop Color-Word Test ranged between -0.01 and -0.31, which is also in the weak-moderate range (Barkley, 2011).

Discriminant Validity of BDEFS-A. Discriminant validity refers to the ability of a scale to discriminate between two groups of subjects (Fitzner, 2007). Barkley (2011) evaluated the discriminate validity by using the BDEFS scale to discriminate between subjects with and without ADHD, which showed that those with ADHD have a higher chance of scoring in the significant range than those without ADHD (control group). In addition, all subscales were used to examine their correlation with IQ and academic achievement; where weak correlations were obtained with academic achievement and only self-organization/problem solving subscale correlated with IQ with an r of -0.15 (negative correlation) and p-value of 0.007 (Barkley, 2011).

Criterion Validity of BDEFS-A. Criterion validity refers to the degree of agreement between the instrument and other tools in measuring the same construct and imply the same outcome (Fitzner, 2007). As for the criterion validity, Barkley (2011) referred to the correlations that were found using the normative sample and pilot studies to investigate how BDEFS scores would relate to concurrent outcomes (Allee-Smith et al., 2013; Barkley, 2011). Hence, BDEFS scores (ADHD index) were compared to other ADHD rating scale scores, and the results showed that BDEFS measures ally with ADHD severity (Allee-Smith et al., 2013; Barkley, 2011).

Conclusion

Executive functioning (EF) research has gained in importance recently (Cristofori et al., 2019; Diamond & Ling, 2016; Engelhardt et al., 2015); yet, little research was done

in Lebanon. Research has shown that there are different definitions proposed for the construct EF; where most tend to regard EF as an umbrella that encompasses multiple cognitive processes that are useful for everyday life activities (Barkley & Fischer, 2011; Cristofori et al., 2019; Jurado & Rosselli, 2007; Vélez-Pastrana et al., 2016). The processes involved in EF include inhibition, working memory, cognitive flexibility, organization and problem solving, reasoning, planning and time management, and self-regulation (i.e. behavior and emotions) (Barkley, 2001; Diamond, 2013; Dohle et al., 2018; Doyle et al., 2006; Kern et al., 2009; Lyvers et al., 2014; Packwood et al., 2011; Suchy et al., 2017; Titz & Karbach, 2014). All of which are significant and essential for individual's daily living in several aspects; this includes academic success, professional life, and social life. For instance, EFs allow individuals to sustain their attention to a certain task, adapt to new situations, achieve goals, generate solutions to problems, inhibit irrelevant actions or responses, regulate their emotions, control and monitor their behavior…etc. (Dehili et al., 2017).

On another note, studies have reported that EFs develop in a non-linear manner and their development varies among individuals of different age groups. Hence, the development of EF is influenced by several factors; this includes age, mental health (e.g. stress), brain structure and functionality, and other environmental conditions. Some EF processes take more time to mature than others, so adults would have them more developed than children. On the other side, there are EF processes that deteriorate with time so young adults would function better in tasks that demand such processes than older adults.

Assessing EF is crucial to identifying any sort of deficits that an individual could have. At times, adults suffer in their daily lives without knowing the underlying cause of

their suffering; this could be exemplified by failing to complete a task when started, or impulsively reacting to situations inappropriately (Cristofori et al., 2019; Diamond & Ling, 2016; Dohle et al., 2018). This could be influencing their academic performance in college, career life, and/or social life (Allee-Smith et al., 2013; Bueno et al., 2017; Cristofori et al., 2019; Diamond, 2013; Kamradt et al., 2021; Lantrip et al., 2016; Meltzer et al., 2017; Titz & Karbach, 2014). Thus, by assessing their EFs individuals would get the opportunity to be aware of their areas of strengths and weaknesses and deal with life accordingly.

It is worth noting that an accurate assessment of EFs should be based on a well-developed instrument with significant features such as psychometric measures, ease of use, administration and scoring…etc. After reviewing literature on BDEFS-A, one can claim that this scale outperforms other tests used to assess EF in terms of administration time, cost-effectiveness, reliability, validity, the relevance of items to individual's real-life contexts, and its comprehensive measure of all EF processes (Allee-Smith et al., 2013).

CHAPTER 3

METHODOLOGY

This chapter presents the methodology that was used in this study. First, we discuss the research design. Then we provide an overview of the tool selected for the adaptation in this study (BDEFS-A) which also has been described. This is followed by describing the sampling procedure and how we administered the adapted BDEFS-A version to our participants. Then we portray the scoring and data analysis procedures that were used after collecting the data.

Research Design

For this study, we used a descriptive quantitative research design. Descriptive quantitative research is nonexperimental design that aims to collect quantifiable data for statistical analysis without manipulating the variables involved in the study (Baker, 2017). Thus, the focus lies on the control variables which are held constant in this study (i.e. gender, age, and educational level).

This study was conducted in various stages. The first step was to adapt the BDEFS-A scale and then have it externally reviewed by two psychologists who are experts in EF construct. We planned to pilot the adapted BDEFS adult's self-rating scale and get feedback from the piloted sample to identify any problems in the adaptation and make the needed edits. However, we were not able to pilot the adapted BDEFS-A self-report rating scale due to challenges faced in the data collection process and time constraints. Hence, the adapted scale was administered on the selected normative sample. Norms were obtained based on the whole sample for each of the five subscales and the full scale.

Finally, we examined the reliability of our adapted version by testing for its internal consistency. We planned to test for the adapted scale's consistency over time using test re-test reliability, but we could not due to challenges faced in data collection process and difficulties in approaching the sample for a 2nd administration of the adapted scale. In addition, the construct and discriminating validity of the BDEFS-A adult's self-rating scale (18-33) were examined.

Sampling Procedure and Sample

Based on the International Test Commission (ITC) guidelines, sample used to fulfill study's purposes, i.e. test validation and adaptation, should be large enough in size to be representative of the population in terms of gender, age, and education (Hambleton, 2005; International Test Commission [ITC], 2017). For that, we used stratified sampling in this study to obtain a representative sample of adults aged 18-33 years who are enrolled in different educational programs (Bachelor's, Master's, and PhD) at the American University of Beirut (AUB).

Stratified sampling is a random sampling procedure that allows every subject from the large population to have an equal chance of being presented in the sample (Etikan, 2017). It involves dividing the large population into sub-groups that are more homogenous than the total population, known as strata (Etikan, 2017). Subjects were then selected in each stratum (sub-population) to a make up a total sample that is representative of the large population (Etikan, 2017).

To recruit our participants proportionally in this study, we looked into the most recently published data of students enrolled at the American University of Beirut (AUB) to select a sample that is representative of the whole target population. For this reason, we

randomly selected students based on the stratification of students enrolled in different education programs (Bachelor, Master, PhD), then we randomly stratified by gender within education into males (M) and females (F). Finally, we sorted them according to the four age groups: 18-21 years; 22-25 years; 26-29 years; 30-33 years.

The participants were randomly selected by the admissions office, which was done by randomly selecting a certain number of participants according to the specified stratifications and sending them the study invitation email. It is worth noting that in order to obtain AUB students email addresses, the HRPP/IRB has been acting as an intermediary with various offices at AUB to secure the requested lists of emails by the investigators to IT Academic Core Processes and Systems (ACPS). The IRB also approved the number of mailing to be sent out as reminders, and how much time should elapse between the mailings; that is usually up to 3 reminders with a gap of one week between each.

Thus, researchers of this study were not informed of any personal information about the participants. Their personal info remained anonymous. Participants received an email with a brief description of the study, its importance, and a link that they can automatically click on to provide their consent for participation and then start with the study by electronically filling out the questionnaire/survey after providing their demographic info (age, gender, educational degree upon completion, major).

The sample for this study was supposed to include around 1100 AUB students (English speaking) aged between 18 and 33 years; enrolled in different programs. The study invitation was sent to an approximation of 81% undergraduates (UG) of which 50% F and 50% M; 17% masters (GR) with 64% F and 36% M; 2% PhD of which 58% F and 42% M. The percentages are based on AUB data on students' enrollment per program and gender

for the academic year 2019-2020 (Appendix A), which is the most recently published on the website. Thus, our sample was supposed to consist of 892 UG students (446 F and 446 M), 187 GR students (120 F and 67 M), and 22 PhD students (13 F and 9 M).

It is important to note that the study invitation was sent to 1,100 AUB students at the initial stage of data collection, but the response rate was very low. One week later, we sent the 1st reminder to the same mail list but still the response rate was considerably low (n=8). We sent the 2nd reminder after almost 10 days but the response rate was still low (n=19). Then, we waited for almost two weeks and sent the 3rd reminder yet the response rate was barely increasing (n=24). For this reason, we had to submit a request to the IRB for them to approve an increase in the sample size of the mail list (n=3000 instead of 1,101). However, they only approved 2,450 students and we had to send 2 reminders until we received almost 117 responses including the incomplete ones, which we then filtered out to finally have 52 complete responses eligible for our data analysis.

Instrument

Barkley Deficits in Executive Functions Scale – Adults

Barkley Deficits in Executive Functions Scale – Adults is one of the commonly used scales to assess executive function deficits of individuals aged 18 to 81 in their daily lives (Allee-Smith et al., 2013; Barkley, 2011). It is individually administered to predict executive function impairments in major life activities. This scale is grounded on theoretical and empirical evidences, and its conceptualization of EF was also based on the literature (Allee-Smith et al., 2013). Although BDEFS-A is not designed for diagnostic purposes, yet it can be used in clinical, research, and/or organizational settings to screen for EF impairments and ADHD in adults (Allee-Smith et al., 2013; Barkley, 2011).

BDEFS-A provides a comprehensive assessment of individual's EF skills by having all five subscales completed: (1) *self-management to time*; (2) *self-organization/problem solving*; (3) *self-restraint*; (4) *self-motivation*; and (5) *self-regulation of emotion* (Barkley, 2011). The first subscale, *self-management to time*, includes items that measure individual's competencies in time management, concentrating, planning, forgetting, and procrastinating (Allee-Smith et al., 2013; Barkley, 2011). The second subscale, *self-organization/problem solving*, includes items that are related to learning, problem-solving skills, ordering and sequencing abilities, and the speed and accuracy of processing information (Allee-Smith et al., 2013; Barkley, 2011). The third subscale, *self-restraint*, includes items that relate to inhibition, impulsivity, and tolerating frustrating situations (Allee-Smith et al., 2013; Barkley, 2011). The fourth subscale, *self-motivation*, includes items that relate to the individual's ability to place consistent effort to reach long-term goals, work under no external supervision, and being determinant (Allee-Smith et al., 2013; Barkley, 2011). Finally, the fifth subscale, *self-regulation of emotion*, includes items that relate to emotional control, objective perception of events and situations, self-relaxing, and emotional reactions to exciting situations (Allee-Smith et al., 2013; Barkley, 2011).

The scale consists of 19 reporting sheets, including all ages and both sexes. They are divided into 15 long forms and 4 short forms (Barkley, 2011).

The long forms (15) are split into two main categories: self-report (14) and other-report (1). The self-report forms are categorized based on age, gender, and type of score. There are four age intervals: 18-34, 35-49, 50-64, and 65-81. For each age interval, there are three forms (males only, females only, and males & females combined). This makes a

total of 12 self-report long forms for raw scores. There's also one long self-report form that is used for all ages and genders which is used to measure the total EF symptom counts.

The short forms are divided into: (1) BDEFS-SF: Self-Report, (2) BDEFS-SF: Other-Report, (3) BDEFS-SF: Self-Report Score Sheet for Total EF Summary Scores and EF Symptom Counts (All Ages and Both Sexes), and (4) BDEFS-SF Clinical Interview: Self-Report (Barkley, 2011).

Adaptation of BDEFS-A

There are certain guidelines that should be carefully taken into consideration when adapting and validating any scale or test. Hambleton (2005) makes reference to scale adaptation guidelines as "a practice that is judged as important for conducting and evaluating the adaptation or parallel development of psychological and educational tests for use in different populations" (p. 21). Thus, the process of validation and adaptation is a complex one which requires the review of the guidelines, developed by the International Test Commission (ITC) that comprehend "the context, test development and adaptation, administration, documentation/score interpretation" (Hambleton, 2005, p. 22, 23).

Adaptation of the Barkley Deficits in Executive Functioning – Adults scales is based on the latest edition (2nd edition) of the International Test Commission Guidelines for translating and adapting tests (2017). The ITC guidelines (2017) state that there could be differences between the target and original population which need to be taken into consideration in the translation and adaptation process of any instrument, which include cultural, linguistic, and psychological differences. The target population is the population for whom the adapted version is intended. This highlights the importance of having qualified professionals who are sufficiently knowledgeable about the cultures, subject

matter (i.e. familiar with the construct), testing principles, and test construction (International Test Commission [ITC], 2017).

Another guideline that we adhere to in this study, is to "provide evidence that the test instructions and item content have similar meaning for all intended populations" (International Test Commission [ITC], 2017, p. 13). This requires having reviewers, being residents or citizens of the target setting, who are well-informed of the local culture and language (International Test Commission [ITC], 2017). The fourth guideline demands us to "provide evidence that the item formats, rating scales, scoring categories, test conventions, modes of administration, and other procedures are suitable for all intended populations" (International Test Commission [ITC], 2017, p.14). The last guidelines will require us to "collect pilot data on the adapted test to enable item analysis, reliability assessment and other small-scale validity studies, so that any necessary revisions to the adapted test can be made" (International Test Commission [ITC], 2017, p.15). Thus, before we initiate any reliability, validity, and/or norming studies to the test scores on a large scale, we will need to having compelling evidences about the psychometric properties of the adapted scale version (International Test Commission [ITC], 2017).

Administration of BDEFS-A

Prior to the administration of the adapted BDEFS-A scale, we had to get the adults' consent to participate in the study. Thus, we first provided the adults with consent form as approved by the Institutional Review Board (IRB). After obtaining their consent, we asked them to provide us with demographic information that allows us to sort their responses by age, gender, and education (degree and major). Then, we started administering the BDEFS-A scale by sharing the questionnaire (self-report form) with the adults through an online

tool known as Lime survey. The form included demographic questions, instructions as provided by the BDEFS-A manual, and the adapted BDEFS-A scale items. Then, participants get to voluntarily complete the forms and submit them, so that researchers will directly receive their responses and sort the collected data based on education, gender within each education level, and age. This facilitates the process of data analysis that is done post data collection.

Knowing that the BDEFS-A scale is a comprehensive EF scale, we administer the scale using the adapted long forms. Thus, the online administration of the adapted BDEFS-A scale should take around 15-20 mins for adults to complete the survey, after having their consent to participate in the study. Explicit directions were provided to the adults (i.e. AUB students) being administered, as part of the survey, to ensure that they are familiar with item formats, instructions, mode of administration, and rating scales. We also left a note for the participants who would like to see their EF results after we collect the data as part of the study invitation, for us to share the results with those interested.

Scoring Procedures

Scoring procedures should be decided on prior to the administration of the scale; they are usually included in the manual of the rating scale. Scoring of the adapted BDEFS-A self-rating scale were based on the guidelines provided by Barkley in the manual. Responses to BDEFS-A items are usually scored based on a 4-point Likert scale ranging from one to four. 1 represents never or rarely, 2 represents sometimes, 3 represents often, and 4 represents very often. Total score of the long form is obtained by tallying the scores obtained in each of the five subscales and adding them up to find their sum. After obtaining

the raw scores, they can be converted into percentile ranks using the appropriate scoring sheet with the precise age group and gender.

Data Analysis Procedure and Assumptions

To answer our main research questions, we had to compute the reliability and validity of the adapted BDEFS-A scale, which required us to decide on the strategies that we will be using to analyze our data.

Reliability Measures

The reliability of the adapted BDEFS-A scale is established by measuring its internal consistency using Cronbach alpha (α) and consistency over time using test-retest using correlation coefficient (r).

Internal Consistency Reliability. Internal consistency determines the consistency of test items within the test itself and it is measured using Cronbach alpha ($\boldsymbol{\alpha}$) (Fitzner, 2007). Thus, it is measured by determining the correlations between test items that are set to measure the same construct. To obtain that, we calculate Cronbach alpha for each of the five subscales of the adapted BDEFS-A scale and for its total self-report rating scale. Based on the results, we report whether the adapted BDEFS-A scale has a satisfactory internal consistency reliability measure ($\boldsymbol{\alpha \geq 0.8}$).

Test-retest Reliability. Test-retest reliability indicates the test's ability to reproduce the same results across different times of administrations with the same individuals (Fitzner, 2007). Thus, it is measured by correlating the test scores over different times of administration. We planned to administer the adapted BDEFS-A twice over a two-week interval to the same individuals. We planned to use Pearson product moment correlation (r)

to measure test-retest reliability for the total self-report rating scale of the adapted BDEFS-A scale. Based on that, we planned to report whether the adapted BDEFS-A scale has a satisfactory test-retest reliability measure ($\mathbf{r} > \mathbf{0}.\mathbf{7}$).

Validity Measures

To ensure that the adapted BDEFS-A scale is valid, we had to collect evidence of construct and discriminant validity. Prior to the collection of evidence, we define each of construct and discriminant validity. Then, we determine whether the adapted BDEFS-A measures the construct that it is supposed to measure (i.e. EF).

Construct Validity. For each of the dimensions/sub-constructs mentioned, construct validity was measured by investigating adults' EF deficits across age, gender, and education based on the self-report rating scale of the adapted BDEFS-A scale. There are several factors that influence the individual's EF abilities, our focus was on age, gender, and education. Based on research, we hypothesize that EF continue to mature in early adulthood meaning that mid-adults (26-33yrs) have less EF deficits than young (18-25yrs). We also assumed that gender differences and education have an impact on EF. Thus, we used t-tests to investigate the differences in the adults' EF by gender and education. As we also used one-way ANOVA to investigate the differences by age group.

Thus, we investigate the following factors: EF and age, EF and gender, and EF and education. To do so, we used three-way Analysis of Variance (ANOVA) which allows us to evaluate if there is a three-way interaction between the three factors (age, gender, and education) and EF deficits between subjects and within subjects.

Discriminant Validity. Discriminant validity refers to the scale's ability to distinguish between subjects (Fitzner, 2007). Based on research and Barkley's

conceptualization of EFs, there is a significant association between ADHD and EF deficits; meaning that individuals with ADHD are more susceptible to have EF deficits than individuals without ADHD. To obtain discriminant validity evidence for the adapted BDEFS-A scale, we select two groups and compare their self-report rating scale scores to evaluate the adapted scale's discriminating abilities. Groups 1 and 2 consist of adults of both gender, education, and age. As part of the demographic questionnaire, students had to indicate whether they are diagnosed with ADHD or not. However, group 1 only consist of adults diagnosed with ADHD by professionals. Group 2 is the control group that consists of adults without ADHD diagnosis. Then, we used t-test to compare the means of both groups and report the distinguishing abilities of the adapted Lebanese BDEFS-A scale.

Norms

Norms were reported in the form of percentile ranks and standard scores for the whole sample. First, we obtain raw scores from the adapted BDEFS-A self-report rating scale for the total EF and each of the five subscales: (1) *self-management to time*; (2) *self-organization/problem solving*; (3) *self-restraint*; (4) *self-motivation*; and (5) *self-regulation of emotion.* Then, we convert these raw scores to percentile ranks for the five subscales of the adapted BDEFS-A self-report rating scale and the total EF deficits. Then, we report the descriptive of our sample study; which includes the mean ($\bar{x}$), and standard deviation (SD). After that, we convert the raw scores into t-scores ($\bar{x}$= 50 and SD= 10); which are standard scores hence making obtained scores easier to interpret with same reference value and compare across sub-scales.

Conclusion

In conclusion, this study is designed for adaptation and validation purposes of the BDEFS-A self-report rating scale. The methodology used to fulfill the study's purpose was based on multi-steps procedure that range from sampling, adaptation procedure, to administration, scoring, and data analysis techniques that were used to collect reliability and validity evidence. First, we adapt the BDEFS-A scale according to the guidelines of the International Test Commission (ITC) from the originally developed for culture, to our target population. Then, we asked two professional educational psychologists who are familiar with the construct EF to review the adapted BDEFS-A version to ensure that they are appropriate with regards to age, culture, and language.

Subsequent to the administration and scoring of the adapted BDEFS-A scale, we employ some statistical analysis techniques to collect evidence for validity and reliability measures. Reliability measures were obtained through the use of Cronbach alpha (α) for internal consistency. Validity evidence are collected through construct and discriminant evidence to validate the adapted BDEFS-A scale with the use of t-tests and ANOVA. Finally, norms were reported based on the sample by reporting the descriptive (mean and standard deviation) and converting the obtained scores into percentile ranks and t-scores for the whole sample.

CHAPTER 4

RESULTS

This chapter reports the results of this study, it will present the data obtained on the normative sample and the psychometric properties of the adapted BDEFS-A self-report rating scale, including the five subscales. The results conducted on the final sample of AUB students self-report rating scale sample consisted of 117 participants, including the incomplete responses yet the final complete responses added up to 52 participants of different ages, gender, and education level.

The investigated reliability of the adapted BDEFS-A self-report rating scale (internal consistency) is presented. In addition, the construct, discriminant validity and Analysis of Variance are reported. A brief description of the developed norms is provided.

Demographics

In this study, we planned to collect data from 1,101 participants of both genders (males and females), within the age groups 18-21, 22-25, 26-29, and 30-33, and different educational levels (undergraduates, graduates, PhD). Due to challenges faced during the data collection process, we were able to have a sample of 117 AUB students including incomplete responses to the self-report rating scale. However, none of the participants were PhD students. After filtering our data, we had a final sample of 52 participants who completed the self-report rating scale.

Out of the 52 participants, only 1 AUB student was within the age group 30-33 which was excluded in several tests run in the data analysis procedure. Table 1 (Appendix

B) presents the number of participants in each of the following groups: gender, age, and education.

Adaptation of BDEFS-A

The BDEFS-A self-report rating scale was reviewed by a psychologist and an educational psychologist from the American University of Beirut and adaptations were made according to their comments to ensure that the adapted rating scale has cultural suitability, age appropriacy, and language adequacy. Hence, they evaluated how accurately each item measured the proposed definition of EF construct and its components when referring to the five subscales. They also checked for cultural bias and found that the items are free from cultural bias. However, they proposed slight changes to be made in the wording of some items. As an example, replace "Unable to think on my feet or respond as effectively as others to unexpected events" with "Unable to respond as effectively as others to unexpected events" for item 37. Since most of the skills assessed in the adapted BDEFS-A self-report rating scale were cross-culturally relevant, none of the items were changed completely.

Reliability

Reliability of test is based on the extent to which this test is free of measurement error. In order to answer research question 1 (Does the adapted BDEFS-A show internal consistency (Cronbach alpha ≥ 0.8?), we measured the internal consistency reliability. We also planned to measure test-retest reliability, but we were not able to do that due to some challenges we faced in the data collection process.

Internal Consistency Reliability

Internal consistency reliability refers to degree to which all items of a particular scale consistently measure the same construct. Therefore, quantitative data was collected by computing the internal reliability coefficient Cronbach's alpha coefficient for each of the five subscales and for the full scale of the adapted BDEFS-A self-report rating scale.

The reliability coefficients Cronbach's alpha of the five subscales of the adapted BDEFS-A self-report rating scale were ranging between $\alpha = 0.43$ and $\alpha = 0.70$, which is considered moderate to high reliability. The Cronbach alpha of the adapted BDEFS-A full self-report rating scale was $\alpha = 0.80$. Going back to research question 1 (Does the adapted BDEFS-A show internal consistency (Cronbach alpha ≥ 0.8), the measured Cronbach alpha reflects good internal consistency of the adapted BDEFS-A scale.

Descriptive statistics and internal reliability coefficients for the adapted BDEFS-A self-report rating scale and subscales are presented in table 2 (Appendix C).

Test-retest Reliability

Test-retest reliability was supposed to be done to test the stability of the adapted BDEFS-A self-report rating over two-week interval of time. However, during the data collection process we faced some challenges in collecting data from the sample size needed. After sending several reminders and targeting more than double the number of participants needed (n=1101), we were only able to get 117 responses. Out of those 117, only 52 were complete responses. For that reason, we were not able to reach the same participants after two weeks from their completion to the questionnaire. Thus, we were not able to investigate the test-retest reliability of the adapted BDEFS-A self-report rating scale and its subscales over two weeks interval.

Validity

To answer research question 2 (Does the adapted BDEFS-A version show evidence of construct and discriminant validity?), we conducted several tests as explained below. T-tests and ANOVA were mainly used to test the construct validity of the adapted BDEFS-A self-report rating scale.

We used t-test to investigate differences in the adults' EF deficits by gender and education, and ANOVA to investigate differences by age. Then, three-way ANOVA was done to investigate the interaction of the three factors: age, gender, and education, if any. As part of the discriminant validity, we examined the adapted BDEFS-A self-report rating scale validity to discriminate between ADHD and non-ADHD groups using a t-test.

Construct Validity

Gender and EF. We used t-test to examine the differences in executive function deficits between males and females. The 18 male participants (M = 173.78, SD = 50.39) compared to the 34 female participants (M = 166.21, SD = 41.18) demonstrated close performance in EF as shown in table 3 (Appendix D). There was no significant effect for gender on EF, $t(50) = 0.58$, $p= 0.56$ at the 5% significance level as shown in table 4 (Appendix D).

Education and EF. We used t-test to examine the differences in executive function deficits between undergraduates and graduates. The 32 undergraduates (M = 177.25, SD = 46.42) demonstrated slightly more EF deficits than the 20 graduates (M = 155.35, SD = 37.77) as shown in table 5 (Appendix E). There was a significance effect for education on

EF deficits within the 10% significance level, t(50) = 1.77, p= 0.08 as shown in table 6 (Appendix E) but not the 5% level.

For this reason, we investigated further by running a t-test to examine the differences in executive function deficits for the five subscales between undergraduates and graduates. We found that there was a significance effect within the 5% significance level for subscale 1 (self-management to time), t (103) = 2.24, p= 0.027 and subscale 3 (self-restraint), t (73) = 2.20, p= 0.031. Results of mean showed that undergraduates have more EF deficits than graduates in subscale 1, meaning that graduates have better self-management to time skills. Similarly for subscale 3, results of mean showed that undergraduates have more EF deficits than graduates, meaning that graduates have better self-restraint skills than undergraduates.

Age and EF. For this measurement, we disregarded the 4th age group (30-33) since there was only 1 participant within this age range, and this hinders the analysis of our data. A one-way between subjects ANOVA was conducted to compare the effect of age on total EF deficits within the 18-21, 22-25, and 26-29 age groups as shown in table 7 (Appendix F). The mean of EF deficits score was higher for the younger age groups than the older ones where M (18-21) < M (22-25) < M (26-29). Yet, there was not a significant effect of age on executive function deficits at the $p<0.05$ level for the 3 age groups [$F(2, 48) = 2.14$, $p = 0.13$] as shown in table 8 (Appendix F).

For this reason, we investigated further by running a t-test to examine the differences in executive function deficits for the five subscales between age group 1 (18-21) and age group 3 (26-29). Descriptive results are presented in table 9 (Appendix F). We found that there was a significance effect within the 5% significance level for subscale 1

(self-management to time), t (42) = 2.30, p= 0.026. Results of mean showed that students of age group 1 (18-21) have more EF deficits than students of age group 3 (26-29) in subscale 1, meaning that older students have better self-management to time skills.

Gender x Age x Education – ANOVA. We used three-way ANOVA to examine the three-way interaction of factors (age, gender, and education) with the total EF deficits. Table 10 (Appendix G) presents the N, Mean (M), and Standard Deviation (SD) of the three factors. Three-way ANOVA failed to produce any results for the age x gender x education interaction with EF deficits, as shown in table 11 (Appendix G). Hence, we took a step further and a two-way ANOVA was performed to evaluate the effects of age and gender, gender and education, and age and education on EF deficits. The means and standard deviations for the mentioned variables are presented in tables 12, 13, and 14 (Appendix G). The results also indicated no significant effect at the $p<0.05$ significance level for gender and age ($F(2, 45) = 0.31$, $p = 0.74$), gender and education ($F(1, 48) = 0.38$, $p= 0.54$), and for education and age ($F(1, 46) = 2.43$, $p= 0.13$).

Discriminant Validity (ADHD and non-ADHD)

To obtain discriminant validity evidence for the adapted BDEFS-A scale and evaluate the adapted scale's discriminating ability, we selected two groups (ADHD and non-ADHD) using the demographic questionnaire where the participants had to mention whether they're diagnosed with ADHD or not. Hence, we did not refer to convenience sampling through clinical settings.

Descriptive of both groups are presented in table 15 (Appendix H). We used t-test to examine the differences in executive function deficits between ADHD and non-ADHD

students. The 43 non-ADHD students (M = 164.84, SD = 44.3) demonstrated less EF deficits than the 9 ADHD students (M = 187.89, SD = 40.84). There was not a significance effect for ADHD on EF deficits within the 5% significance level, t(50) = -1.44, p= 0.157 as shown in table 16 (Appendix H).

Norms Development

To develop the norms, we considered the whole sample as there were no significant differences between genders, age groups and education and converted the raw scores of EF deficits of the adapted BDEFS-A self-report rating scale into percentile ranks and T-scores for each of the five subscales ((1) *self-management to time*; (2) *self-organization/problem solving*; (3) *self-restraint*; (4) *self-motivation*; and (5) *self-regulation of emotion*) and the full scale. The raw EF deficit scores ranged from 26 to 81 for subscale 1, 24 to 86 for subscale 2, 19 to 60 for subscale 3, 12 to 47 for subscale 4, 13 to 49 for subscale 5. As for the full scale, EF deficit scores ranged between 100 and 268.

The percentile ranks are presented in table 17 (Appendix I) along with the mean and standard deviation for each of the five subscales and the full adapted BDEFS-A scale. Scores were also standardized by t-scores converting the raw scores into z-scores (z= (x-mean)/SD), then computed t-scores (t=50+z(10) as presented in table 18, 19, 20, 21, 22, 23(Appendix I).

Conclusion

In summary, this study examined the reliability and validity of an adapted version of the BDEFS-A self-report rating scale for executive function (EF) deficits among AUB

students. Although the sample size and demographic distribution posed some limitations, the results provided insights into the psychometric properties of the scale.

For internal consistency reliability, the full-scale Cronbach's alpha reached 0.80, indicating good reliability, while the five subscales showed moderate to high consistency. Despite planning for test-retest reliability, data collection challenges prevented the required follow-up.

Regarding construct validity, the findings from t-tests and ANOVA indicated no significant differences in EF deficits based on gender, age, or education. The analysis of Pearson correlations and three-way ANOVA yielded weak or insignificant interactions among these factors. Discriminant validity, examined through the comparison of ADHD and non-ADHD groups, did not reveal significant effects, suggesting the adapted scale's limited ability to distinguish between these groups and this could be due to the small sample size.

The study also demonstrated the adaptability of the scale to a culturally diverse population. Adaptations made in collaboration with educational psychologists ensured cultural suitability without the need to make significant changes to the original items. Normative data were established by converting raw scores into percentile ranks and t-scores for each of the five subscale and the full scale.

While the study provides a foundational understanding of the adapted BDEFS-A scale, it also highlights the need for further research. Future studies should focus on increasing the sample size, achieving a broader demographic representation, and conducting test-retest reliability to ensure consistency over time. Furthermore, additional analysis, such as factor analysis, could also help refine the scale's construct validity.

In conclusion, despite its limitations, this study contributes to the ongoing validation of the BDEFS-A self-report rating scale, offering a useful tool for assessing executive function deficits in a university setting. With continued research and refinement, the adapted scale has the potential to support both academic and clinical evaluations of executive function deficits.

CHAPTER 5

DISCUSSION

The results of this study contribute to the understanding of the psychometric properties of the adapted BDEFS-A self-report rating scale within a sample of AUB students. In this discussion, we interpret these findings, considering their implications for assessing executive function (EF) deficits and addressing the limitations encountered during the study.

Adaptation of BDEFS-A

The aim of this study was to validate and adapt the Barkley Deficits in Executive Functions Scale for adults that can be utilized to evaluate the deficits in executive functions within the Lebanese context. Executive functioning as a construct covers diverse skills which include self-management to time, self-organization and problem solving, self-restraint/inhibition, self-motivation, and self-regulation of emotion. The study assessed the psychometric properties of the adapted BDEFS – A scale since they serve as the basis for future uses of this scale in clinical applications and studies within the Lebanese community. The findings of this study provide evidence that the transcultural adaptation of BDEFS-A within the Lebanese community was fairly acceptable. Moreover, the adapted BDEFS-A version proved the eligibility and accuracy of the scale to measure the deficits in EFs after adapting to the target population.

The adapted BDEFS-A version was reviewed by two professionals, a psychologist and an educational psychologist, who are familiar with the construct EF to ensure the adapted scale has cultural suitability, age appropriacy, and language adequacy. Based on

the professional's evaluation of the BDEFS-A self-report, each executive function item reviewed shown no cultural bias.

Gender, Age, and Degree Effect

The study adopted a two-way ANOVA to evaluate the effects of age and gender, gender and education, and age and education on EF deficits. The results indicated no significant effect at the $p<0.05$ significance level for gender and age, gender and education, and for education and age. These findings could be attributed to the fact that the sample sizes within the groups of education and age were relatively small that is why they found no significant effect at $p<0.05$ significant level for education and age.

Regarding the age and executive functions of adults, the present study's findings showed that there was no significant effect of age on the total executive function deficits at the $p<0.05$ level. However, the older group had lower EF deficits scores compared to the younger group and this led us to investigate further into the subscales. We found that there was a significant effect in subscale 1 (self-management to time) where older group had better self-management to time skills. The inconsistency of these findings across the overall scale with the literature could be attributed to the small sample size used in this study, especially after disregarding the 4^{th} age group (30-33). Therefore, although the adapted BDEFS-A version failed to prove that the adapted scale has age-appropriate validity, the lack of significance of effect of age on executive functioning could be a result of small sample size and having more than half of the respondents from one age group (18-21, n= 34). Consequently, future studies should consider using respondents from age groups differing in age to be able to understand the true effects of age on executive function

impairments. In addition, future studies should consider having some source of extrinsic motivation for the participants, such as incentives for participation. This is because we had students who were not motivated to respond and felt like they were being spammed by the invitation mail which they were receiving so they asked us to stop sending them.

The fundamental element of EF is the working memory, which is the ability to hold on to new information to enable the brain to work with it while performing tasks. According to Gutchess et al. (2007), working memory declines with age, but the decline level differs among people. This decline of EF abilities with age could be attributed to the loss of cognitive function that prepares individuals' brain to receive new information. The cognitive function is susceptible to decline with age making it difficult for older adults to assess things properly. The study also found age group and education have significant effect on the executive function in some subscales. The finding is consistent with Zahodne et al. (2015) findings regarding the role of education in helping to protect against cognitive decline. The study established that the more education people have, the greater their working memory, thus enhancing their executive functioning (Zahodne et al., 2015).

EF is one of the capabilities to fruitfully choose and control information and utilize it properly to attain a goal. According to Grady (2012), individuals with advanced age often experience cognitive deficits in various aspects. Executive functioning reduces in older adults making even the simplest tasks difficult for advanced age adults, yet they continue to mature in early adulthood which aligns with the results of our sample. The reviewing of the adaptation of BDEFS-A was to ensure the adapted scale has age appropriacy to understand if there are age-related decline in EF abilities between young adults and older adults. However, the findings failed to show statistical significant effects of age on executive

functioning at the $p<0.05$ level. The results shows that the five EF ability are hardly affected by the aging process compared to other executive functions that seem to decline in their abilities with age signaling the beginning of cognitive impairment (Lonie et al., 2009). Our findings mirror the findings of Langenecker et al. (2004) that found no age differences in the Stroop effect which could also be attributed to the variations in the age groups and sample sizes used in this study. Yet, our findings show that there was a significance effect in EF deficits at the $p<0.05$ level for one of the subscales (subscale 1: self-management to time) between age groups 18-21 and 26-29. This proves that with time, individuals continue to develop their self-management to time skills as mentioned by (Cristofori et al., 2019; Diamond, 2013).

Developing of Norms

Despite the challenges faced during data collection, this study developed initial norms for the adapted BDEFS-A self-report rating scale by converting raw scores into percentile ranks and t-scores for the five subscales and the full scale. These norms can serve as a baseline for future research and clinical applications, providing a reference point for evaluating EF among university students. In this present study, norms were reported in the form of percentile ranks and standard scores for the whole sample. To develop the norms, the present study considered the whole sample and converted the raw scores of EF deficits of the adapted BDEFS-A self-report rating scale into percentile ranks and T-scores for each of the five subscales ((1) *self-management to time*; (2) *self-organization/problem solving*; (3) *self-restraint*; (4) *self-motivation*; and (5) *self-regulation of emotion*) and the full scale.

In the following, we compared the mean scores and standard deviations of our sample to the means and standards deviations of the original norms developed for the five subscales to better interpret the norms we developed (Barkley, 2011, p. 64). Based on the findings, the participants reported fairly higher level of EF deficit score for subscale 1 (M= 45.76, SD= 12.79) compared to the original data norms by Barkley (2011) (M= 36.7, SD= 11.8), thus proving that this sample had more deficits in time-management skills during data collection. Also, the participants reported higher level of EF deficit score for subscale 2 (M= 43.76, SD=15.25) relative to the raw EF scores norms (M= 36.7, SD= 12.3), also providing evidence that this sample had more EF deficits in self-organization skills during data collection. Regarding subscale 3 (M=31.18, SD=9.7) reported somehow the same level of EF deficit score compared to the raw EF deficits score norms (M= 30, SD= 9.6), further proving that this sample had similar self-restraint and inhibition skills compared to the original sample of the BDEFS-A scale. The 4th subscale items (M=20.86, SD=8.20) reported higher level of EF deficit score compared to the raw EF deficits score norms (M=16.5, SD=5.8) meaning that this sample had more deficits in self-motivation skills compared to the raw EF deficit score norms. The 5th subscale items (M=26.47, SD=8.41) also reported higher level of EF deficit score compared to the raw EF deficits score norms (M=20.5, SD=8.0) meaning that this sample seem to have more deficits in self-regulation skills compared to the raw EF deficit score norms.

However, subscales 1, 2, and 3 had high standard deviation, indicating that their data norms are more spread out from their means compared to subscales 4 and 5 whose data are tightly clustered around their means.

However, according to Beerten-Duijkers *et al.* (2019), there are only norms for the overall rating of EF on the BDEFS-Short scale calculated by summing up the overall raw scores from all the items and establishing the proper SD score in the manual. Barkley (2011) chose the four highest loading questions from each of the five EF items discovered as part of the factor analyses of the BDEFS-LF to develop BDEFS-SF.

Reliability of BDEFS-A

Internal Consistency Reliability

The internal consistency reliability results for the adapted BDEFS-A self-report rating scale are promising, with a full-scale Cronbach's alpha of 0.80, indicating good reliability. This level of consistency suggests that the adapted scale is a reliable measure for assessing EF among university students. However, the reliability coefficients for the five subscales ranged from moderate to high, indicating room for improvement, particularly in the lower end of this range. The inability to conduct test-retest reliability due to data collection challenges remains a limitation, suggesting that future studies should prioritize obtaining a larger and more consistent sample for longitudinal reliability assessments.

The reliability coefficients Cronbach's alpha of the five subscales of the adapted BDEFS-A self-report rating scale were ranging between $\alpha = 0.43$ and $\alpha = 0.70$, which is considered moderate to high reliability. Based on the measured Cronbach alpha, it reflects good internal consistency of the adapted BDEFS-A scale. Regarding the subscale 1, the average score for the subscale 1 on the adapted scale was 47.13, out of the maximum score of 84, with a high standard deviation of 14.23 showing that data is clustered around the mean. The average score for subscale 2 was 45.59 out of the maximum score of 89, with a

high standard deviation of 15.96, showing the data is closer to the mean and that there are minimal variations. Regarding, subscale 3, the average score on the adapted scale was 34.04 out of maximum score of 76, with a high standard deviation of 11.33, also showing that data is closer to the mean. These results show that the adapted BDEFS-A self-report rating scale is a reliable measure for assessing EF deficits among the Lebanese adult population.

Moreover, the study also measured internal consistency of the adapted BDEFS-A self-report rating scale by calculating Cronbach's alpha for the five subscales and the overall score. The findings were as follows: Cronbach's alpha for Self-management to time was 0 .60, self-organization/problem solving was 0.70, self-restraint was 0.52, self-motivation was 0.43, self-regulation was 0.43, and total EF deficits score was 0.80. In this respect, the adapted BDEFS-A self-report rating scale depicted fairly high values for internal consistency which is similar to original questionnaire's values.

Furthermore, the reliability coefficient for BDEFS-A total deficit summary score for subscale 1 among the participants mirrored past studies, underlining outstanding internal reliability for BDEFS-A and also supporting the instrument as the measure of overall EF deficits (Sheble, 2018). It is vital to understand that possible clinical utilization of BDEFS-A within the Lebanese context will depend on the future research on the factor analytical procedures and the amalgamation of additional norms for Lebanese population that is representative of various regions, socioeconomic levels, and other vital demographic factors. According to Barkley (2011), the utilization of the community control group helped to establish the cut-off for clinical norms for EF deficits, specialized as 1.5 SDs above the

group's mean on the prototype BDEFS. Therefore, when utilizing such cut-off, the participants had significantly higher scores on the overall subscale items.

Validity of BDEFS-A

The investigation into construct and discriminant validity provided mixed results.

Construct Validity Variance Analysis – ANOVA

The t-tests and ANOVA analyses showed no significant differences in EF deficits based on gender, age, or education. This indicates that these demographic factors might not significantly influence EF as measured by the adapted BDEFS-A scale within this particular sample. However, the results could also reflect the limited sample size and uneven distribution across age groups, with only one participant in the 30-33 age groups (Idowu, & Szameitat, 2023). The study conducted by Idowu, & Szameitat (2023) established age-related decline in all the four executive functions in the tasks employed, showing importance of having uneven distribution across age groups.

The study performed a factor analysis using the adapted BDEFS-A scale to establish if the measures of the EF items were comparable construct as identified in Barkley (2011). Based on the literature review of executive functioning, Barkley's extended phenotype theory stated that executive functioning deficiencies and ADHD were comparable object (Barkley, 2012). In this respect, there is a need for the factor analysis or t-test to portray one construct when using the BDEFS items and ADHD. More importantly, the factor analysis presented a high factor loading onto the construct, further supporting the Barkley's theory executive functioning and attention-deficit/hyperactivity disorder (ADHD) are just names for a similar construct (Barkley, 2011). The present study replicated this factor analysis

with the participants completing the adapted BDFS-A scale and the findings were matching.

Generally, the findings of this study support the validity of the adapted BDEFS-A scale as a reliable and consistent tool that can be utilized to examine the executive functioning within the Lebanese context. Hyperactivity-impulsivity, inattention, and sex symptoms appear to somewhat affect performance of certain BDFEFS items and were also evidently associated with the BDEFS factor means. Therefore, there is a need for future studies to consider exploring the impact of sex differences across these executive functioning factors among young college adults to establish if the existence of these variations is connected to other validity elements of BDEFS-A. Notwithstanding these variations, the findings of this study proves that the adapted BDEFS-A is a strong measure to capture different elements of EF deficits among Lebanese adult population.

Discriminant Validity

The study's discriminant validity analysis, which compared EF deficits between ADHD and non-ADHD groups, did not reveal significant differences. This finding may indicate that the adapted scale is not robust enough to distinguish between these groups, or it could point to the small sample size and reliance on self-reported ADHD diagnosis. Further research with larger, clinically validated samples is needed to clarify these results (Barkley, 2011). Data from the adapted BDEFS analysis showed that the majority of the adults with ADHD belonged to the clinical range of above the 93rd percentile, SD= 1.5 above the mean across all the BDEFS subscales against the 8-11 percentile across several factors in the community control group as established by Barkley (2011) utilizing the self-

report data. Based on this understanding, it seems there is excellent discriminant validity in differentiating between control groups and adults with ADHD.

However, it is important to note that the clinical control group as stated in Barkley (2011) were in the clinically significant range of 83-98 percentile which can be attributed to the self-report aspect result of this measure. Based on Barkley (2011), based on the self-report information, over 45 percent of the adults that were in the clinical control group depicted adequate ADHD symptoms to satisfy the diagnostic measures. In this respect, adults in the clinical control group are also likely to depict adequate symptoms meet the BDEFS-A measuring scale. Based on this information, it is evident that the adapted BDEFS-A is sufficient at discerning the standard population from the clinical population as established in Barkley (2011). More importantly, the present study conducted an evaluation using the adapted BDEFS-A measuring scale containing five-factor items. Based on the findings, we were able to adapt the BDEFS-A scale and obtain its reliability, and some sort of validity for education for two subscales and for 1 subscale regarding the age group. Moreover, we developed the norms which can serve as a base to build on in future studies within the Lebanese context.

Implications Findings to Theory and Practice in the Lebanese Context

This study makes a significant contribution to the field by adapting and validating psychometric properties of the adapted BDEFS-A, thus offering a realistic and valid alternative for assessing executive function deficits in the Lebanese context, mainly AUB community. Often, studies and clinical measures that are culturally sensitive and in proper languages tend to be unavailable. Furthermore, from a global point of view, there is a need

to have international collaborations to benefit significantly from the availability of measures of construct like BDEFS-A in applicable languages, with required psychometric documentation. These are aspects that this study examined to validate and adapt BDEFS measure to be used to assess EF deficits among population in the Lebanese context.

The fundamental implications of this study's findings are the identification of a new BDEFS-A rating scale that can better test Lebanese adults with EF deficits. Furthermore, the adapted BDEFS-A scale could be utilized by Lebanese universities' professionals like academic counselors, mental health counselors, and medical practitioners to identify students that may require more extensive evaluations. Similarly, the study also showed that the adapted BDEFS-A scale can be very useful in discriminating the adult people with and without EF deficits, thus can be a valid and realistic screening tool for EF deficits in the Lebanese context.

Furthermore, the study's findings show that the adapted five-factor model of the BDEFS-A scale can be used to measure the EF deficits among Lebanese adult population as manifested in its reliability and validity. Moreover, the adapted BDEFS-A rating scores reflecting the executive functioning deficits across the five items can be measured using this scale with sufficient consistency. The study's findings also offer support for the interpretations' validity of these scores across sex, education, age, and ADHD symptoms. The findings also showed support for invariance across age, gender, and educations. Consequently, our study will contribute to the field of study by assessing the BDEFS-A in the non-clinical, multi-site Lebanese population, where identifying executive functioning deficits is likely to have significant implications.

Furthermore, our findings' support for the adapted BDEFS-A scale's validity shows that its measures can be utilized to identify Lebanese adults, especially college students who are at-risk of EF deficits. For instance, a study by Munro et al. (2017) established that college students suffering from EF deficits tend to report considerably higher rates of using nonmedical stimulants compared to those without these deficits. Furthermore, such students tend to experience difficulties with assessing the repercussions of their actions which exposes them to high risk-taking activities. Therefore, assessment of the executive functioning deficits among Lebanese adults could help in the identification of those who are at risk for such problems, thus helping to introduce realistic coping tools and help generate and achieve suitable personal and career goals.

Limitations and Recommendations for Future Research

The most significant limitation of this study was the small sample size and its uneven distribution across age groups and educational levels. Additionally, the absence of PhD students and the lack of test-retest reliability measurements limited the study's scope. The inability to verify ADHD diagnoses through clinical records also constrained the analysis of discriminant validity.

Future studies should focus on expanding the sample size and achieving a more balanced demographic representation. Incorporating test-retest reliability and exploring additional factors that could influence EF, such as socioeconomic status and academic performance, would strengthen the scale's validation. Additionally, further analysis using advanced statistical techniques, such as factor analysis, could provide deeper insights into the scale's construct validity.

Moreover, since this study focused on validating the adapted BDEFS-A scale using the college sample, the age range of the respondents was significantly narrower compared to the BDEFS normative sample range of 18-29 years vs. 18-81 years. In this respect, there is a need for future studies on this topic to consider using the sample with larger age range. Furthermore, future studies should also consider exploring if the findings of this present study can accurately apply to non-college adults of comparable age.

Conclusion

This study offers valuable insights into the reliability and validity of the adapted BDEFS-A self-report rating scale among AUB students, indicating good internal consistency but highlighting the need for further research to establish more robust validity evidence. Despite the limitations, the study's findings contribute to the ongoing evaluation of executive function assessment tools and lay the groundwork for future studies in this domain.

In addition, having ascertained the validity of the adapted BDEFS-A, this rating scale could be further developed on a larger sample, this is more representative of the AUB population, to be utilized in the identification of impairment areas and implement more effective counseling with AUB students and adults. The adapted BDEFS-A is recommended as realistic and consistent rating scale with proven reliability in English language for testing EF deficits while overcoming the previously mentioned limitations of EF’s lab-based tests. Furthermore, experts also ascertained that the adapted BDEFS-A rating scale also has norms that can be built on for future studies that could lead to clinical utilization.

APPENDIX A

ENROLLMENT DATA BY THE AMERICAN UNIVERSITY OF BEIRUT

Enrollment by Faculty and Percent by Gender Fall 2019–20

Faculty	Enrollment	Female%	Male%
UNDERGRADUATE LEVEL			
FAFS	373	75%	25%
FAS	3005	54%	46%
MSFEA	2394	38%	62%
FHS	262	71%	29%
HSON	193	68%	32%
OSB	1133	48%	52%
Total	7360	50%	50%
GRADUATE LEVEL			
FAFS	107	76%	24%
FAH	13	92%	8%

Faculty	Enrollment	Female%	Male%
FAS	482	67%	33%
MSFEA	337	46%	54%
FEM	30	60%	40%
FM	122	80%	20%
FHS	136	87%	13%
FMH	6	67%	33%
HSON	55	80%	20%
OSB	252	50%	50%
Total	1540	64%	36%
POST GRADUATE LEVEL			
FAS	33	73%	27%
MSFEA	86	43%	57%
FEM	12	58%	42%
FM	26	81%	19%
FHS	5	80%	20%
HSON	6	83%	17%
Total	168	58%	42%

APPENDIX B

DEMOGRAPHICS

Table 1

Distribution of Participants by Gender, Age Group, and Education

Gender	**Male**	**18**
	Female	34
Age Group	18-21	30
	22-25	7
	26-29	14
	30-33	1
Education	Undergraduate	32
	Graduate	20

APPENDIX C

INTERNAL CONSISTENCY RELIABILITY

Table 2

Mean (M), Standard Deviation (SD) and Coefficient Alpha for The Adapted BDEFS-A Self-Report Rating Scale and Its Subscales

	N	Range	Minimum	Maximum	Mean (M)	Std. Deviation (SD)	Cronbach alpha (α)
Subscale 1 self-management to time	103	60	24	84	47.13	14.23	0.60
Subscale 2 self-organization/problem solving	80	65	24	89	45.59	15.96	0.70
Subscale 3 self-restraint	75	57	19	76	34.04	11.33	0.52
Subscale 4 self-motivation	73	36	12	48	21.58	8.45	0.43
Subscale 5 self-regulation	72	36	13	49	27.57	8.99	0.43
Total EF deficits	52	168	100	268	168.83	44.24	0.80
Valid N (listwise)	52						

APPENDIX D

CONSTRUCT VALIDITY – GENDER AND EF

Table 3

Mean (M), Standard Deviation (SD) for The Males X EF Deficits and Females X EF Deficits of The Adapted BDEFS-A Self-Report Rating Scale

Gender		N	Mean	Std. Deviation	Std. Error Mean
Total EF deficits	Male	18	173.78	50.39	11.88
	Female	34	166.21	41.18	7.06

Table 4

T-Test for The Males X EF Deficits and Females X EF Deficits of The Adapted BDEFS-A Self-Report Rating Scale

				t-test for Equality of Means						
				t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Total EF deficits	Equal variances assumed	1.65	0.21	0.58	50	0.56	7.57	12.98	-18.5	33.64
	Equal variances not assumed			0.59	29.26	0.59	7.57	13.82	-20.68	35.82

APPENDIX E

EDUCATION AND EF

Table 5

Mean (M), Standard Deviation (SD) For The Undergraduates X EF Deficits and Graduates X EF Deficits of The Adapted BDEFS-A Self-Report Rating Scale

Education		N	Mean	Std. Deviation	Std. Error Mean
Total EF deficits	Undergraduate	32	177.25	46.42	8.21
	Graduate	20	155.35	37.77	8.45

Table 6

T-Test for The Undergraduates X EF Deficits And Graduates X EF Deficits of The Adapted BDEFS-A Self-Report Rating Scale

				t-test for Equality of Means						
				t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Total EF deficits	Equal variances assumed	2.12	0.15	1.77	50	0.08	21.9	12.35	-2.91	46.71
	Equal variances not assumed			1.86	46.44	0.07	21.9	11.78	-1.8	45.6

APPENDIX F

CONSTRUCT VALIDITY – AGE AND EF

Table 7

Mean (M), Standard Deviation (SD), and N of the three age groups' total EF deficits: 18-21, 22-25, 26-29

	N	Mean (M)	Std. Deviation (SD)	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
18-21	30	178.47	46.11	8.42	161.25	195.68	116	268
22-25	7	156.29	25.178	9.52	133.00	179.57	125	206
26-29	14	151.57	43.55	11.64	126.43	176.72	100	258
Total	51	168.04	44.31	6.20	155.58	180.50	100	268

Table 8

One-Way ANOVA Results Between the Three Age Groups

Total EF deficits					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8025.6	2	4012.8	2.14	0.13
Within Groups	90122.32	48	1877.55		
Total	98147.92	50			

Table 9

Mean (M), Standard Deviation (SD), and N of The Two Age Groups' EF Deficits: 18-21 And 26-29 for The Five Subscales

Age Group		**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Subscale 1 Self-management to time	18-21	30	48.93	13.96	2.55
	26-29	14	39.50	9.13	2.44

Subscale 2 **Self-organization / problem solving**	18-21	30	46.87	14.93	2.73
	26-29	14	40.14	17.56	4.69
Subscale 3 **Self-restraint**	18-21	30	33.43	10.03	1.83
	26-29	14	27.50	9.04	2.42
Subscale 4 **Self-motivation**	18-21	30	22.27	8.88	1.62
	26-29	14	19.21	8.19	2.19
Subscale 5 **Self-regulation**	18-21	30	26.97	8.21	1.50
	26-29	14	25.21	9.63	2.57

APPENDIX G

GENDER X AGE X EDUCATION

Table 10

Mean (M), Standard Deviation (SD), and N of Gender X Age Group X Education of The EF Deficits of The Adapted BDEFS-A Self-Report Rating Scale

Dependent Variable:	**Total EF deficits**				
Gender			Mean	Std. Deviation	N
Male	18-21	Undergraduate	181.08	57.04	12
		Total	181.08	57.04	12
	22-25	Undergraduate	206.00		1
		Graduate	152.00		1
		Total	179.00	38.18	2
	26-29	Graduate	149.25	30.61	4
		Total	149.25	30.61	4
	Total	Undergraduate	183.00	55.05	13
		Graduate	149.80	26.54	5
		Total	173.78	50.39	18
Female	18-21	Undergraduate	176.72	38.91	18
		Total	176.72	38.91	18
	22-25	Graduate	147.20	15.01	5

		Total	147.20	15.01	5
	26-29	Undergraduate	112.00		1
		Graduate	157.00	49.99	9
		Total	152.50	49.24	10
	30-33	Graduate	209.00		1
		Total	209.00		1
	Total	Undergraduate	173.32	40.62	19
		Graduate	157.20	41.47	15
		Total	166.21	41.18	34
Total	18-21	Undergraduate	178.47	46.11	30
		Total	178.47	46.11	30
	22-25	Undergraduate	206.00		1
		Graduate	148.00	13.57	6
		Total	156.29	25.18	7
	26-29	Undergraduate	112.00		1
		Graduate	154.62	43.75	13
		Total	151.57	43.55	14
	30-33	Graduate	209.00		1
		Total	209.00		1
	Total	Undergraduate	177.25	46.42	32
		Graduate	155.35	37.77	20
		Total	168.83	44.24	52

Table 11

ANOVA Results for The EF of Gender X Age Group X Education Three-Way Interaction

Dependent Variable:	Total EF deficits				
Source	Type III Sum of Squares				
Corrected Model	**14563.37[a]**	**df**	**Mean Square**	**F**	**Sig.**
Intercept	########	8	1820.42	0.92	0.51
Gender	4.54	1	########	194.91	0.00
AgeGroup	4487.28	1	4.54	0.00	0.96
Education	26.04	3	1495.76	0.76	0.53
Gender * AgeGroup	100.89	1	26.04	0.01	0.91
Gender * Education	0.00	1	100.89	0.05	0.82
AgeGroup * Education	0.00	0			
Gender * AgeGroup * Education	0.00	0			
Error	85230.08	0			
Total	########	43	1982.10		

Corrected Total	99793.44	52

Table 12

Two-Way ANOVA Results for The EF Deficits of Gender X Age Group

Dependent Variable:	**Total EF deficits**				
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11282.87[a]	6	1880.48	0.96	0.47
Intercept	########	1	########	248.44	0.00
Gender	911.05	1	911.05	0.46	0.50
AgeGroup	8923.47	3	2974.49	1.51	0.22
Gender * AgeGroup	1214.55	2	607.28	0.31	0.74
Error	88510.58	45	1966.90		
Total	########	52			
Corrected Total	99793.44	51			

a. R Squared = .113 (Adjusted R Squared = -.005)

Table 13

Two-Way ANOVA Results for The EF Deficits of Gender X Education

Dependent Variable:	**Total EF deficits**				
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6832.14[a]	3	2277.38	1.18	0.33
Intercept	1110459.77	1	########	573.38	0.00
Gender	13.17	1	13.17	0.01	0.94
Education	6138.10	1	6138.10	3.17	0.08
Gender * Education	736.63	1	736.63	0.38	0.54
Error	92961.31	48	1936.69		
Total	1581925.00	52			
Corrected Total	99793.44	51			

a. R Squared = .068 (Adjusted R Squared = .010)

Table 14

Two-Way ANOVA Results for The EF Deficits of Education X Age Group

Dependent Variable:	**Total EF deficits**				
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14240.80[a]	5	2848.18	1.53	0.20
Intercept	316150.13	1	316150.13	169.99	0.00
Education	105.50	1	105.50	0.06	0.81
AgeGroup	7447.17	3	2482.39	1.34	0.28
Education * AgeGroup	4512.17	1	4512.17	2.43	0.13
Error	85552.54	46	1859.84		
Total	1581925.00	52			
Corrected Total	99793.442	51			

a. R Squared = .143 (Adjusted R Squared = .050)

APPENDIX H

DISCRIMINANT VALIDITY – ADHD AND NON-ADHD

Table 15

Mean, Standard Deviation, and N of ADHD and non-ADHD EF Deficits

Dependent Variable:	**Total EF deficits**		
ADHD	Mean	Std. Deviation	N
Non-ADHD	164.84	44.32	43
ADHD	187.89	40.84	9
Total	168.83	44.24	52

Table 16

T-Test for EF Deficits Scores of Non-ADHD and ADHD Students

				t-test for Equality of Means						
				t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
									Lower	Upper
Total EF	Equal variances assumed	0.036	0.850	-1.44	50	0.157	-23.05	16.05	-55.29	9.18
	Equal variances not assumed			-1.52	12.29	0.155	-23.05	15.2	-56.08	9.98

APPENDIX I

NORMS DEVELOPMENT

Table 17

Mean (M), Standard Deviation (SD), N, and Percentile Ranks of EF Deficits for The Five Subscales and Full BDEFS-A Adapted Scale

		Subscale 1 Self-management to time	Subscale 2 Self-organization/ problem solving	Subscale 3 Self-restraint	Subscale 4 Self-motivation	Subscale 5 Self-regulation	Total EF deficits
N	Valid	51	51	51	51	51	51
	Missing	0	0	0	0	0	0
Mean		45.76	43.76	31.18	20.86	26.47	168.04
Std. Deviation		12.79	15.25	9.7	8.20	8.41	44.31
Percentiles	10	29.00	27.00	20.00	13.00	14.20	116.20
	20	34.00	30.40	21.40	14.00	17.80	129.60
	30	39.00	34.00	23.60	15.00	21.60	139.60
	40	41.80	36.00	28.00	17.80	23.00	150.20
	50	44.00	40.00	29.00	18.00	26.00	158.00
	60	47.00	44.20	31.00	21.00	30.00	167.00
	70	50.00	48.60	35.40	22.40	33.40	188.00
	80	58.40	56.60	41.20	26.60	35.00	200.40
	90	65.20	66.00	44.80	34.80	37.80	244.40

Table 18

Percentile Ranks & Standard Scores for The Total EF Deficit Scores of The Adapted BDEFS-A Scale

	Total EF	zEF	tEF	%ile
Mean EF	100	-1.56	34.4 - 37	6.06%
168.83	110	-1.33	36.70	9.27%
SD EF	112	-1.28	37.15	10.04%
44.42	114	-1.24	37.61	10.85%
	116	-1.19	38.06	11.72%
	117	-1.17	38.28	12.16%
	119	-1.13	38.74	13.10%
	119	-1.13	38.74	13.10%
	125	-0.99	40.09	16.19%
	126	-0.97	40.32	16.75%
	135	-0.76	42.35	22.32%
	136	-0.74	42.58	22.99%
	137	-0.72	42.81	23.68%
	139	-0.67	43.26	25.09%
	139	-0.67	43.26	25.09%
	140	-0.65	43.48	25.82%
	141	-0.63	43.71	26.55%
	142	-0.61	43.94	27.29%
	143	-0.58	44.16	28.05%
	143	-0.58	44.16	28.05%
	152	-0.38	46.20	35.24%
	153	-0.36	46.42	36.08%

	153	-0.36	46.42	36.08%
	154	-0.34	46.65	36.92%
	157	-0.27	47.33	39.50%
	158	-0.24	47.55	40.37%
	161	-0.18	48.23	43.00%
	164	-0.11	48.91	45.67%
	165	-0.09	49.13	46.56%
	165	-0.09	49.13	46.56%
	165	-0.09	49.13	46.56%
	175	0.14	51.39	55.52%
	181	0.28	52.75	60.79%
	182	0.30	52.98	61.66%
	187	0.41	54.11	65.87%
	188	0.43	54.33	66.70%
	188	0.43	54.33	66.70%
	189	0.46	54.56	67.51%
	189	0.46	54.56	67.51%
	190	0.48	54.79	68.32%
	192	0.52	55.24	69.90%
	206	0.84	58.40	79.86%
	209	0.91	59.08	81.71%
	219	1.13	61.34	87.06%
	223	1.22	62.24	88.87%
	225	1.27	62.70	89.70%
	238	1.56	65.64	94.03%
	246	1.74	67.44	95.88%
	258	2.02	70.16	97.76%
	261	2.08	70.83	98.10%

	265	2.17	71.74	98.48%
	268	2.24	72.42	98.72%

Table 19

Percentile Ranks & Standard Scores for Subscale 1 EF Deficit Scores of The Adapted BDEFS-A Scale

S1	**z1**	**t1**	**%ile**
Mean	26		6.88%
S1		-1.48	35.15	
47.13	28	-1.34	36.56	8.94%
SD S1	28	-1.34	36.56	8.94%
14.23	29	-1.27	37.26	10.13%
	29	-1.27	37.26	10.13%
	29	-1.27	37.26	10.13%
	30	-1.20	37.96	11.43%
	31	-1.13	38.66	12.85%
	32	-1.06	39.37	14.38%
	34	-0.92	40.77	17.81%
	34	-0.92	40.77	17.81%
	35	-0.85	41.48	19.70%
	38	-0.64	43.58	26.06%
	38	-0.64	43.58	26.06%
	39	-0.57	44.29	28.39%
	39	-0.57	44.29	28.39%
	39	-0.57	44.29	28.39%
	39	-0.57	44.29	28.39%
	40	-0.50	44.99	30.82%
	41	-0.43	45.69	33.33%

	42	-0.36	46.39	35.92%
	43	-0.29	47.10	38.58%
	43	-0.29	47.10	38.58%
	43	-0.29	47.10	38.58%
	44	-0.22	47.80	41.30%
	44	-0.22	47.80	41.30%
	45	-0.15	48.50	44.05%
	46	-0.08	49.21	46.84%
	46	-0.08	49.21	46.84%
	46	-0.08	49.21	46.84%
	47	-0.01	49.91	49.64%
	47	-0.01	49.91	49.64%
	47	-0.01	49.91	49.64%
	49	0.13	51.31	55.23%
	50	0.20	52.02	57.99%
	50	0.20	52.02	57.99%
	50	0.20	52.02	57.99%
	51	0.27	52.72	60.72%
	53	0.41	54.13	66.00%
	53	0.41	54.13	66.00%
	56	0.62	56.23	73.35%
	60	0.90	59.04	81.71%
	60	0.90	59.04	81.71%
	61	0.97	59.75	83.51%
	61	0.97	59.75	83.51%
	61	0.97	59.75	83.51%
	62	1.04	60.45	85.20%
	66	1.33	63.26	90.76%

	66	1.33	63.26	90.76%
	70	1.61	66.07	94.60%
	73	1.82	68.18	96.55%
	81	2.38	73.80	99.13%

Table 20

Percentile Ranks & Standard Scores for Subscale 2 EF Deficit Scores of The Adapted BDEFS-A Scale

	S2	**Z2**	**t2**	**%ile**
Mean	24			8.81%
S2		-1.35	36.47	
45.59	24	-1.35	36.47	8.81%
SD S2	26	-1.23	37.73	10.98%
15.96	27	-1.16	38.35	12.21%
	27	-1.16	38.35	12.21%
	27	-1.16	38.35	12.21%
	28	-1.10	38.98	13.52%
	29	-1.04	39.61	14.93%
	29	-1.04	39.61	14.93%
	30	-0.98	40.23	16.43%
	31	-0.91	40.86	18.03%
	31	-0.91	40.86	18.03%
	33	-0.79	42.11	21.51%
	33	-0.79	42.11	21.51%
	34	-0.73	42.74	23.39%
	34	-0.73	42.74	23.39%
	35	-0.66	43.36	25.35%
	35	-0.66	43.36	25.35%

	35	-0.66	43.36	25.35%
	36	-0.60	43.99	27.40%
	36	-0.60	43.99	27.40%
	36	-0.60	43.99	27.40%
	38	-0.48	45.24	31.72%
	39	-0.41	45.87	33.98%
	39	-0.41	45.87	33.98%
	40	-0.35	46.50	36.31%
	41	-0.29	47.12	38.68%
	41	-0.29	47.12	38.68%
	42	-0.22	47.75	41.10%
	43	-0.16	48.38	43.55%
	44	-0.10	49.00	46.03%
	44	-0.10	49.00	46.03%
	45	-0.04	49.63	48.53%
	45	-0.04	49.63	48.53%
	45	-0.04	49.63	48.53%
	46	0.03	50.26	51.02%
	47	0.09	50.88	53.52%
	51	0.34	53.39	63.27%
	54	0.53	55.27	70.09%
	54	0.53	55.27	70.09%
	55	0.59	55.90	72.23%
	56	0.65	56.52	74.29%
	57	0.71	57.15	76.27%
	61	0.97	59.66	83.29%
	62	1.03	60.28	84.81%
	65	1.22	62.16	88.80%

	66	1.28	62.79	89.95%
	66	1.28	62.79	89.95%
	67	1.34	63.41	91.01%
	78	2.03	70.31	97.89%
	79	2.09	70.93	98.18%
	86	2.53	75.32	99.43%

Table 21

Percentile Ranks & Standard Scores for Subscale 3 EF Deficit Scores of The Adapted BDEFS-A Scale

S3	**Z3**	**t3**	**%ile**
Mean S3	19	-1.33	36.73	9.22%
34.04	19	-1.33	36.73	9.22%
SD S3	20	-1.24	37.61	10.76%
11.33	20	-1.24	37.61	10.76%
	20	-1.24	37.61	10.76%
	20	-1.24	37.61	10.76%
	20	-1.24	37.61	10.76%
	21	-1.15	38.49	12.49%
	21	-1.15	38.49	12.49%
	21	-1.15	38.49	12.49%
	22	-1.06	39.37	14.40%
	22	-1.06	39.37	14.40%
	23	-0.97	40.26	16.49%
	23	-0.97	40.26	16.49%
	23	-0.97	40.26	16.49%
	24	-0.89	41.14	18.78%

	24	-0.89	41.14	18.78%
	27	-0.62	43.79	26.72%
	27	-0.62	43.79	26.72%
	28	-0.53	44.67	29.70%
	28	-0.53	44.67	29.70%
	28	-0.53	44.67	29.70%
	29	-0.44	45.55	32.82%
	29	-0.44	45.55	32.82%
	29	-0.44	45.55	32.82%
	29	-0.44	45.55	32.82%
	29	-0.44	45.55	32.82%
	30	-0.36	46.43	36.07%
	30	-0.36	46.43	36.07%
	31	-0.27	47.32	39.42%
	31	-0.27	47.32	39.42%
	31	-0.27	47.32	39.42%
	33	-0.09	49.08	46.34%
	35	0.08	50.85	53.38%
	35	0.08	50.85	53.38%
	35	0.08	50.85	53.38%
	36	0.17	51.73	56.87%
	36	0.17	51.73	56.87%
	37	0.26	52.61	60.31%
	39	0.44	54.38	66.92%
	40	0.53	55.26	70.06%
	40	0.53	55.26	70.06%
	42	0.70	57.03	75.88%
	42	0.70	57.03	75.88%

	43	0.79	57.91	78.55%
	43	0.79	57.91	78.55%
	44	0.88	58.79	81.03%
	45	0.97	59.67	83.33%
	47	1.14	61.44	87.37%
	49	1.32	63.20	90.66%
	50	1.41	64.09	92.05%
	60	2.29	72.91	98.90%

Table 22

Percentile Ranks & Standard Scores for Subscale 4 EF Deficit Scores of The Adapted BDEFS-A Scale

S4	**Z4**	**t4**	**%ile**
Mean	12		12.85%
S4	-1.13	38.66	
21.58	12	-1.13	38.66	12.85%
SD S4	13	-1.02	39.85	15.50%
8.45	13	-1.02	39.85	15.50%
	13	-1.02	39.85	15.50%
	13	-1.02	39.85	15.50%
	13	-1.02	39.85	15.50%
	13	-1.02	39.85	15.50%
	13	-1.02	39.85	15.50%
	14	-0.90	41.03	18.48%
	14	-0.90	41.03	18.48%
	14	-0.90	41.03	18.48%
	15	-0.78	42.21	21.81%
	15	-0.78	42.21	21.81%

	15	-0.78	42.21	21.81%
	15	-0.78	42.21	21.81%
	15	-0.78	42.21	21.81%
	15	-0.78	42.21	21.81%
	16	-0.66	43.40	25.45%
	17	-0.54	44.58	29.39%
	17	-0.54	44.58	29.39%
	18	-0.42	45.76	33.59%
	18	-0.42	45.76	33.59%
	18	-0.42	45.76	33.59%
	18	-0.42	45.76	33.59%
	18	-0.42	45.76	33.59%
	18	-0.42	45.76	33.59%
	19	-0.31	46.95	38.01%
	19	-0.31	46.95	38.01%
	19	-0.31	46.95	38.01%
	20	-0.19	48.13	42.58%
	21	-0.07	49.31	47.26%
	21	-0.07	49.31	47.26%
	21	-0.07	49.31	47.26%
	21	-0.07	49.31	47.26%
	21	-0.07	49.31	47.26%
	22	0.05	50.50	51.98%
	23	0.17	51.68	56.67%
	24	0.29	52.86	61.27%
	25	0.40	54.05	65.72%
	26	0.52	55.23	69.95%
	26	0.52	55.23	69.95%

	27	0.64	56.41	73.94%
	28	0.76	57.60	77.63%
	32	1.23	62.33	89.12%
	33	1.35	63.51	91.17%
	34	1.47	64.70	92.92%
	35	1.59	65.88	94.39%
	35	1.59	65.88	94.39%
	37	1.82	68.25	96.60%
	40	2.18	71.80	98.54%
	47	3.01	80.08	99.87%

Table 23

Percentile Ranks & Standard Scores for Subscale 5 EF Deficit Scores of The Adapted BDEFS-A Scale

S5	**Z5**	**t5**	**%ile**
Mean	13		5.25%
S5	-1.62	33.79	
27.57	13	-1.62	33.79	5.25%
SD S5	13	-1.62	33.79	5.25%
8.99	13	-1.62	33.79	5.25%
	14	-1.51	34.91	6.56%
	15	-1.40	36.02	8.10%
	15	-1.40	36.02	8.10%
	16	-1.29	37.13	9.90%
	17	-1.18	38.24	11.98%
	17	-1.18	38.24	11.98%

	19	-0.95	40.47	17.02%
	19	-0.95	40.47	17.02%
	19	-0.95	40.47	17.02%
	21	-0.73	42.69	23.24%
	21	-0.73	42.69	23.24%
	22	-0.62	43.80	26.78%
	22	-0.62	43.80	26.78%
	22	-0.62	43.80	26.78%
	22	-0.62	43.80	26.78%
	23	-0.51	44.92	30.56%
	23	-0.51	44.92	30.56%
	24	-0.40	46.03	34.56%
	25	-0.29	47.14	38.75%
	25	-0.29	47.14	38.75%
	26	-0.17	48.25	43.07%
	26	-0.17	48.25	43.07%
	26	-0.17	48.25	43.07%
	26	-0.17	48.25	43.07%
	27	-0.06	49.37	47.47%
	29	0.16	51.59	56.32%
	30	0.27	52.70	60.65%
	30	0.27	52.70	60.65%
	31	0.38	53.82	64.86%
	32	0.49	54.93	68.89%
	33	0.60	56.04	72.71%
	33	0.60	56.04	72.71%
	34	0.72	57.15	76.28%
	34	0.72	57.15	76.28%

	34	0.72	57.15	76.28%
	34	0.72	57.15	76.28%
	35	0.83	58.26	79.57%
	35	0.83	58.26	79.57%
	36	0.94	59.38	82.58%
	36	0.94	59.38	82.58%
	37	1.05	60.49	85.29%
	37	1.05	60.49	85.29%
	38	1.16	61.60	87.70%
	38	1.16	61.60	87.70%
	39	1.27	62.71	89.82%
	40	1.38	63.83	91.66%
	41	1.49	64.94	93.24%
	49	2.38	73.84	99.14%

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