A VALIDATION STUDY FOR THE CHILDHOOD EXECUTIVE FUNCTIONING INVENTORY: BEHAVIORAL CORRELATES OF EXECUTIVE FUNCTIONING

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Thesis Abstract

Ezgi Kayhan, “A Validation Study for the Childhood Executive Functioning Inventory: Behavioral Correlates of Executive Functioning”

The primary aim of this study was to conduct a validation study for the Childhood Executive Functioning Inventory (CHEXI; Thorell & Nyberg, 2008), a behavioral measure of executive functions. Moreover, it was aimed to determine the associations between the Wisconsin Card Sorting Test (WCST) and the CHEXI in order to provide information regarding the behavioral correlates of the WCST. Additionally, it was intended to provide a global knowledge with regard to the developmental status of basic cognitive abilities; such as working memory, fluid intelligence and executive functions, in early school-aged children.

Accordingly, 134 first and second grade children were evaluated by their parents via the CHEXI, and 129 of these participants were rated by their class teachers as well, via using the same instrument. Additionally, the participants were assessed by performance-based instruments of executive functions, working memory and fluid intelligence abilities. Results indicated that the CHEXI seems to provide valid and reliable data regarding the daily-life executive functionality of early school-aged children. Furthermore, results demonstrated that the WCST poorly correlates with the daily-life executive functioning, as measured by the CHEXI. Additionally, significant intercorrelations were obtained between executive functions and other basic cognitive skills such as working memory and fluid intelligence.

Tez Özeti

Ezgi Kayhan, “Çocukluk Dönemi Yönetici İşlevler Envanteri

için bir Geçerlik Çalışması: Yönetici İşlevlerin Davranışsal Eşlenikleri”

Bu çalışma, temel olarak, yönetici işlevleri davranışsal olarak ölçen Çocukluk Dönemi Yönetici İşlevler Envanteri’nin (ÇDYİE; Thorell & Nyberg, 2008) geçerlik çalışmasını yürütmeyi hedeflemektedir. Dahası, bu çalışma, Wisconsin Kart Eşleme Testi (WKET)ve ÇDYİE arasındaki ilişkileri belirleyerek WKET’in davranışsal eşleniklerine dair bilgi sağlamayı amaçlamaktadır. Ek olarak, erken okul çağı çocuklarında, çalışma belleği, akışkan zeka ve yönetici işlevler gibi temel bilişsel yetilerin gelişimsel durumuna ilişkin genel bilgi verebilmek hedeflenmektedir.

Bu doğrultuda, 134 birinci ve ikinci sınıf öğrencisi, ÇDYİE kullanılarak, ebeveynleri tarafından değerlendirilmiştir. Katılımcıların 129’u, yine ÇDYİE kullanılarak sınıf öğretmenleri tarafından da ölçülmüşlerdir. Ek olarak, katılımcılar, yönetici işlevler, çalışma belleği ve akışkan zeka yetilerini ölçen performans temelli testler yoluyla değerlendirilmişlerdir. Sonuçlar, ÇDYİE’nin, erken okul çağı çocuklarının, günlük yaşama ait yönetici işlevselliklerine ilişkin geçerli ve güvenilir veri sağlayan bir değerlendirme aracı olduğunu göstermiştir. Dahası, WKET’in, günlük yaşama ait bir yönetici işlevsellik ölçeği olan ÇDYİE ile düşük korelasyonlar gösterdiği görülmüştür. Ek olarak, yönetici işlevler ile çalışma belleği ve akışkan zeka gibi diğer temel bilişsel yetiler arasında anlamlı korelasyonlar elde edilmiştir.

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CHAPTER 1

INTRODUCTION

Executive functions refer to a set of capacities that enable the individual to perform purposeful goal-oriented behaviors (Lezak, 1995). As widely accepted, executive functioning is an umbrella term that encompasses several lower-level abilities such as working memory, inhibition and cognitive flexibility (Anderson, 2001; Barkley, 2001; Chan, Shum, Toulopoulou & Chen, 2008).

Clinical neuropsychology literature consists of several assessment tools aiming to capture executive abilities. Assessment procedures in executive functionality are basically divided into two categories referring to cognitive assessments and behavioral ratings. Cognitive assessment procedures are conducted in clinical settings aiming to reveal the maximum cognitive performance of the individual in a time period. The Wisconsin Card Sorting Test (WCST; Berg, 1948; Heaton, 1981) is one of the most frequently used cognitive instruments that capture executive abilities in a wide range. On the other hand, behavioral assessment procedures often depend on the ratings of parents and teachers who could observe the executive performance of the individual in different settings and for longer period of times. The Childhood Executive Functioning Inventory (CHEXI; Thorell & Nyberg, 2008) is a new behavioral rating instrument that depends on parent and teacher evaluations to capture daily-life executive functionality of children between the ages of four and seven.

There is a growing body of literature focusing on the generalizability of test scores obtained in clinical settings to naturalistic environments referring to ecological validity phenomenon. Overall, this study primarily aims to conduct a validity study of the Turkish version of the CHEXI. Secondly, it is purposed to determine the correlations between the WCST and the CHEXI in order to provide information regarding the ecological validity (behavioral correlates) of the WCST. Moreover, it is also aimed to contribute to the previous studies in the literature that purpose to define cognitive abilities captured by the WCST. Furthermore, this study intends to obtain the relationship among basic cognitive capacities such as working memory, fluid intelligence and executive functions in early school-aged children. Finally, the present study aims to find out the effects of demographic characteristics (e.g. grade, gender) on children's cognitive functioning.

Definitions of the Term and Theories Related to Executive Functions

Despite of being a highly investigated realm in the neuropsychology literature, the difficulty of finding an agreed definition of executive functions still continues. While a group of researchers focus on the dominance view to explain executive functioning, other authors regard executive functioning as an integration of many different cognitive abilities that are related to each other.

The group of researchers suggesting the dominance view encapsulates executive functions as basic cognitive abilities controlling goal-directed behaviors (Anderson, 2001; De Frais, Dixon & Strauss, 2006; Kimberg & Farah, 1993; Kimberg, D'Esposito & Farah, 1997). However, there is also a lack of agreement between the arguments defining executive functions in terms of a *dominant* mechanism. Authors that stand up for dominance view regards cognitive processes like inhibition or working memory as the *basic* agencies of executive functioning phenomenon (Barkley, 2005; Brocki & Bohlin, 2004; Kimberg & Farah, 1993; Pennington, Bennetto, McAleer & Roberts, 1996).

The group of researchers presenting the second statement defines executive functioning as an extensive umbrella concept including several subcomponents that impact all cognitive abilities, emotional responses and overt behaviors (Anderson, 2001; Barkley, 2001). The subcomponents of executive functions refer to different cognitive abilities such as attention, cognitive flexibility, conceptual thinking, planning, working memory, response inhibition, impulse control, shifting and problem solving (Chan et al., 2008; Lafleche & Albert, 1995).These researchers regard executive functions as independent abilities according to the studies that individuals with lesions of frontal lobe, which is accepted as the primary area responsible for executive functions, could maintain some cognitive abilities, despite of the loss of some other specific frontal lobe abilities (Godefroy, 2003). In other words, the impairment of some specific frontal lobe areas does not impact the global frontal activity so that the unspoiled parts can maintain their functionality due to working independently.

An alternative point of view in the conceptualization of executive functions centers on the studies of Miyake, Friedman, Emerson, Witzki, & Howerter (2000) presenting three principal components of executive functions. These parts of executive functions correspond to inhibition, shifting and updating abilities. Inhibition refers to the ability to restrain a dominant response when it is needed to present a more relevant behavior.

Shifting is regarded as the falling back of a response which is not appropriate to maintain a goal, and changing it with a more suitable one. Lastly, updating is known as the evaluation of new information in terms of its relevance to the existent ones as well as afterwards revision of the information stored in memory. This group of researchers combines the aforementioned two arguments stating that executive functions have some shared properties despite of being independent structures. It is suggested by these scholars that frontal lobe operations are distinct mechanisms; however, they share some underlying common properties. According to Miyake and his colleagues (2000), executive functions consist of the stated three subcomponents that are separable but also related with each other.

Executive functions compromise a wide range of conceptualizations with several classifications and theories. The diversity of point of views in defining executive functions gives rise to the development of multiple theories. There exist many theories related to executive functions; however, within the scope of this study, a few of them will be reviewed. These theories are as follows: (1) Baddeley's the Multi-Component Model (2) Norman and Shallice's Supervisory Attentional System (3) Fuster's Theory of Frontal Lobe Functions. (4) Damasio's the Somatic Marker Hypothesis. Additionally, alternative views will be briefly mentioned.

One of the first theories that relate to executive functions is proposed by Baddeley and Hitch (1974), named "A Model of Working Memory (The Multi-Component Model)". This model consists of three components that correspond to two "slave" mechanisms and an executive system. Two of these slave mechanisms are the phonological loop and visuo-spatial sketchpad (Baddeley, 1998). The phonological loop is composed of a phonological storage that keeps short-term (approximately 2 sc.) verbal information and an articulator loop which saves information by repetition. Furthermore, the visuo-spatial sketchpad is responsible for the storage of visual information. The mechanism that executes the aforementioned two mechanisms is called “the central executive”. The central executive is regarded as an upper level mechanism that includes and controls some main cognitive mechanisms such as attention. Additionally, the central executive controls and regulates the aforementioned two “slave” mechanisms as well (Baddeley, 1996, 1998, 2000, 2002). The central executive gathers information coming from different sources in order to constitute coherent knowledge. Nonetheless, the central executive does not possess the ability to store information coming from external stimuli (Baddeley & Loogie 1999; Baddeley, 2000). Both the limited, short-term storage capacity of the phonological loop and the central executive’s lacking storage property gradually generates the need to add a new concept into the theory.

In his 2000 study, Baddeley proposes the third subsystem named “the episodic buffer” responsible for the integration of information into cognitive operations. In other words, the episodic buffer connects information coming from verbal and visual realms in order to form comprehensive information. This mechanism also links information stored in long term memory to the aforementioned comprehensive knowledge. Episodic buffer is also directed by the central executive as the other two slave systems. In conclusion, Baddeley’s working memory system refers to an organization that includes the storage and use of information in order to attain goals which are related to cognitive abilities such as reasoning or learning. In that sense, Baddeley's model is concerned with processes regarded as executive functions.

The following theoretical framework in the explanation of executive functions corresponds to Norman and Shallice's (2000) "Supervisory Attentional System (SAS)". This system is suggested to be responsible for anticipating the following responses, planning the next step during the execution of a specific operation, and accomplishing the mission of responding appropriately against particularly unfamiliar stimuli. Norman and Shallice's model classifies cognitive processes into two clusters. Automatic (routine) operations refer to familiar situations faced in our daily routines (e.g. drinking water, eating) that can be conducted without deliberate control. On the other hand, controlled (non-routine) operations necessitate abilities such as decision making, planning and rule shifting. These types of actions emerge as a result of problem situations, novel conditions, dangerous stimuli, difficult tasks and in the manipulation of powerful processes such as learning history. Coping with these situations requires mechanisms other than the ones responsible for automatic processes.

One of the basic conceptualizations of Norman and Shallice's (2000) theory is "active schemas" which refer to a set of potential mechanisms that wait on a stand by condition in order to be selected in an appropriate situation to control behaviors. However, sometimes a variety of schemas might be activated for a single situation. At these times, another basic mechanism regulates the situation and activates a selected schema while suppressing less suitable ones at the same time. This process is called "contention scheduling". This type of activation generally exists in familiar situations, that is to say, in conditions where potential schemas effectively work. However, in some situations, existent schemas may be inadequate to control the action. Especially while performing novel or complex tasks, current schemas may not be usable as effective as they are in automatic situations. Scholars suggest that an extra control structure, called “Supervisory Attentional System (SAS), becomes activated to control actions in unfamiliar situations. This system steps in contention scheduling in terms of regulating extra activation or inhibition of some schemas, but not selection of them directly. Consequently, the aforementioned theorists focus on the deliberate control of both automatic and controlled processes in terms of inhibiting unwanted behaviors while allowing appropriate ones. Thus, this conceptualization forms the center of inhibition abilities, and accordingly executive functions.

Another conceptualization related to executive functions is presented by Fuster (1980, 1989, 1995, as cited in Barkley, 2005) called “Fuster’s Theory of Prefrontal Lobe Functions”. Fuster states that the function of the prefrontal cortex is the construction of “cross-temporal” arrangements of actions that have a common goal. The prefrontal cortex is considered to be responsible for the integration of “temporally” apart aspects of behaviors and cognitions in order to attain a goal. This function requires the collaboration of the prefrontal cortex with some other subcortical structures. To Fuster, the functions of the prefrontal cortex are as follows: (1) a “retrospective function” which refers to the holding of information about previous events which are kept temporally in terms of being related to a goal. Additionally, Fuster states that “provisional memory” is used for this function. He argues that this function of memory is provisional because it is used until attaining a goal, and then released from the memory. Moreover, he suggests another concept called “prospective function" that refers to a preparation act that is faced in the anticipation of an event. Fuster calls this preparation process as "the anticipatory set". Furthermore, these aforementioned two functions bring about "hindsight" and "foresight" processes which might be related to working memory process. (3) Finally, Fuster states "inhibition and interference control" on which the prospective and retrospective functions are dependent to show their functionality. The last function allows for the delay which is needed for the other two functions in order to prepare "cross-temporal" constructions that are necessary in goal-oriented actions as well as in protecting them during the goal attainment process. In summary, the existence of inhibitory control necessary for the delay of inappropriate actions that is needed for the preparation of "cross-temporal" structures, and keeping this delay process away from distorting effects are regarded as basic underlying mechanisms of executive functions.

The final of the basic theories in executive functionality depends on Damasio's "The Somatic Marker Hypothesis (1995)". Damasio (1995) proposes a different point of view and emphasizes the importance of affective/motivational factors in executive functioning processes, particularly decision making. Authors defending this theory propose that emotional processes are highly involved in cognitive processes such as decision making (Bechara, H. Damasio & A. R. Damasio, 2000). After a series of experiments, Damasio (1995) concluded that people, at the first step, make intuitional choices based on emotional guidance, which refers to somatic markers. First of all, they decide on the action on a non-conscious level in the light of emotional cues inferred from the previous experiences. In other words, they do not select to perform a behavior due to merely conscious analyses. Besides enhancing decision making processes, these somatic markers are regarded as supports for the operations of other executive agents such as working memory and attention. These somatic signals are accepted to be responsible for the maintenance of attention and working memory processes (Damasio, 1995).

This group of authors further suggests the idea that explicit cognitive information cannot be sufficient to make appropriate decisions because most of the time the primary determinants are non-conscious (Damasio, 1995). Authors argue that people with frontal lesions might maintain intellectual abilities as well as executive functions demonstrated by normal scores even in the WCST and other well known executive function tests. However, the difficulty resides in the inability to apply well-preserved social knowledge to appropriate situations due to the lack of emotional guidance (Bechara et al., 2000).

Furthermore, Bechara et al. (2000) carried out skin conductance response (SCR) experiments to support the idea that decision making is an emotionally colored phenomenon. They measured physiological activation while performing Iowa Gambling Task, which is known to assess decision making, among normal participants and patients with ventromedial (VM) cortex problems. They discovered that normal subjects, in relation to VM patients, demonstrated SCRs before selecting a card, especially the risky ones. On the other hand, VM patients did not show any SCRs before choosing cards. As a result, authors suggest that emotional signals (as they call somatic markers) interfere and direct decision-making processes in healthy populations especially in uncertain situations.

Overall, according to Damasio (1995), decision making is composed of two steps. He accepts "high reason" postulation as the first one in which advantageous and disadvantageous parts of actions are analyzed in detail. Moreover, as a second way, he mentions the utility of somatic cues working as reward and punishment valences of chosen actions where complex and longstanding pros and cons evaluations are not possible. Damasio suggests that the information of somatic cues is used in order to organize decision making steps in complex situations. In complex and ambiguous states, these emotion signals help individuals gain time for responding appropriately, which might possess a survival value. Since they depend on outcomes of previous experiences, they make uncertain situations more familiar and controlling (Damasio, 1996). To sum up, these researchers (Bechara & Damasio, 2005) claim that executive functioning is not a merely cognitive process, it is rather colored by somatic and emotional repertoire.

Finally, an alternative view in the explanation of executive functions is proposed by Zelazo (2003). Researchers supporting this perspective disagree with the idea of an upper level central executive controlling executive functions. According to Zelazo (2003) and Blair, Zelazo & Greenberg (2005), executive functions are the sum of a comprehensive and complex structure that consists of executive subcomponents working together to attain a goal. Some of the subcomponents of executive functions refer to attention, planning, working memory and inhibitory control (Zelazo, Craik & Booth, 2004). By this account, executive functioning is a structure that cannot be limited into a single brain area (i.e. prefrontal cortex), and necessitates co-working of all brain regions (Zelazo, 2003).

Moreover, Zelazo & Müller (2002; as cited in Hongwanishkul, Happaney, Lee & Zelazo, 2004) divide executive abilities into two parts as “hot” and “cool” executive functions (for a similar conceptualization, see Ardila, 2008). Authors suggest that cool executive abilities refer to traditional cognitive assessment of executive abilities which demand the activation of dorsolateral prefrontal cortex. On the other hand, “hot” executive abilities consist of affective aspects which are tapped by ventro-medial regions of the prefrontal cortex. For instance, these authors suggest that cool executive abilities are in charge in abstract tasks (e.g. the Wisconsin Card Sorting Test) whereas hot executive abilities are responsible for affect regulation and motivation problems. As a result, authors emphasize to capture both aspects of executive functions, which brings together to pay more attention on affective aspects to compensate.

Biological Considerations of Executive Functions

A plethora of studies in the literature demonstrates that the prefrontal cortex is the primary realm responsible for the executive functioning (McCabe, Roediger, McDaniel, Balota &Hambrick, 2010; Royall et al., 2002; Stuss & Alexander, 2000). Three of the most widely emphasized frontal areas in executive functioning literature refer to dorsolateral prefrontal cortex, orbitofrontal circuits and anterior cingulate cortex (Anderson, 2001; Royall et al., 2002; Stuss & Alexander, 2000).

Dorsolateral preferontal cortex is considered to be related to the basic executive abilities such as working memory, organization, self-monitoring, problem solving and cognitive flexibility (Anderson, 2001; Manchester, Priestly & Jackson, 2004; Royall et al., 2002; Stuss & Alexander, 2000). Orbitofrontal circuits are regarded to be responsible for inhibitory control, emotion regulation and socially acceptable behaviors (Anderson, 2001; Royall et al., 2002). More broadly, there are also studies in the literature stressing the importance of ventro-medial prefrontal cortex which are considered to be responsible for decision making processes. To Bechara et al. (2000), ventro-medial regions are highly responsible in the appropriateness of emotional processes and social behaviors. The dysfunctions of these areas cause inabilities in the assessment of social circumstances and in the analysis of cost and benefits in problem situations in order to accomplish daily-life requirements for survival. Finally, this body of literature focuses on the activation of anterior cingulate cortex tapping skills such as initiation ability, emotion regulation and motivation which are considered to be important in executive functioning processes (Anderson, 2001; Posner, Rothbart, Sheese & Tang, 2007).

Developmental Considerations of Executive Functions

Studies indicate the correspondence between frontal lobe maturation and developmental trajectory of executive functions (Anderson 2001; Gathercole, Pickering, Ambridge & Wearing, 2004). It is widely accepted that executive functions start to emerge in infancy and improve through childhood to adolescence.

Welsh et al. (1991; as cited in Anderson, 2001) demonstrated that the development of executive functions trace a stage-like development with three basic steps. Authors suggest that the first spurt occurs at the age of six, the next one around the age of ten and the final one is observed in adolescence years. Additionally, this study indicates that combating with interfering stimuli is the first skill to mature around the age of 6.

However, if we regard attention as one of the executive functioning skills, it might be reasonable to suggest that attention is the first executive skill developing in infancy years (Greenspan & Wieder, 2006). On the other hand, there are also studies in the literature suggesting that one of the first executive abilities, namely inhibition, emerges between 0-2 years (Diamond & Goldman-Rakic, 1989; as cited in Di Pinto, 2006).

Epsy, Kaufmann, McDiarmid & Glisky (1999) demonstrated that relatively advanced executive abilities such as shifting and goal setting start to emerge at the age of four and become more mature at the age of five and six. Furthermore, Di Pinto (2006) states that despite of the lack of consistencies in the studies, the development of executive abilities between the ages of six to twelve includes more advanced inhibitory skills, cognitive flexibility and organizational skills. More relevant to the current study, it is stated that cognitive flexibility ability captured by the WCST (Chelune & Baer, 1986; as cited in Di Pinto, 2006; Roselli & Ardila, 1993) has not yet gained an agreed maturation period. In that sense, Di Pinto (2006) points to a wide range and states that this executive ability matures in a period between the ages of 6 to 12. Since human brain is on a rapid improvement during childhood years, it may be hard to determine precise ages for the development of cognitive abilities, especially for extensive skills such as executive functions.

Basic Related Concepts

Since executive functioning is considered to be an extensive phenomenon capturing several different abilities, there are a variety of concepts that are accepted to be related with the executive abilities. The literature consists of several studies regarding the relations between executive functions and other cognitive skills; however, within the scope of this review the most modal ones; working memory and general fluid intelligence, will be evaluated. Additionally, the relations between these two basic concepts; working memory and fluid intelligence, will be considered.

Executive Functions and Working Memory

Theories of working memory construct was primarily presented by Baddeley & Hitch (1974) capturing two slave systems as phonological loop and visuo-spatial sketchpad in addition to a master executive component, namely the central executive. In a nutshell, working memory refers to the ability to store and manipulate information temporarily, and this ability is commonly assessed by procedures such as complex span tasks, simple digit or word span tasks and recalling spatial locations of items (Conway et al., 2005; Gathercole et al., 2008; Oberauer & Lange, 2009) Additionally, despite of being on debate (Engle, Tuholski, Laughlin & Conway, 1999; Friedman & Miyake, 2000; Kane et al., 2004), working memory abilities are basically divided into two categories as verbal and visuo-spatial working memory (Haavisto & Lehto, 2004; Macintosh & Bennett, 2003). Verbal working memory generally captures management of verbal or phonological stimuli (e.g. digit or word spans) whereas visuo-spatial working memory usually focuses on nonverbal and symbolic stimuli (Haavistio & Lehto,2004; Macintosh & Bennett, 2003).

Developmental studies in the literature suggest that working memory concept emerges at the age of four, gains a spurt at the age of six and keeps on developing during adolescence years (Gathercole et al., 2004). These authors argue that at least before the age of six, like most of the cognitive abilities, it is not feasible to specify working memory abilities in domains. Moreover, Tillman, Nyberg & Bohlin (2008) demonstrated in a 6- to13-year-old sample that it is possible to reach domain-specific results in working memory while predicting intelligence abilities. Nevertheless, a debate regarding the specificity of working memory abilities in children (and also adults) still continues (Leeuwen, Berg, Hoekstra & Boomsma, 2009).

Studies in the literature demonstrate significant correlations between working memory and executive function constructs (Lehto, 1996; McCabe et al., 2010). However, working memory construct is also regarded to be one of the executive abilities (McCabe et al., 2010). Since executive functions cover several different abilities, it does not seem easy to specifically differentiate, and accordingly relate executive abilities with other cognitive skills.

The underpinnings of executive functioning and working memory constructs receive different identifications across studies. The consensus reached at the conceptualizations seems to rely on “attention” and “executive control” processes (Engle et al., 1999; Logan, 2003). Currently, McCabe et al. (2010) suggest that the underlying ability that binds executive functioning and working memory can be regarded as “executive attention” since both concepts highly require the management of attention and organization abilities in novel and complex situations.

Executive Functions and Fluid Intelligence

General fluid intelligence (*gf*) captures reasoning and problem solving abilities especially in unfamiliar situations (Engle et al., 1999). From a developmental perspective, general fluid intelligence is also considered to be a dynamic construct developing with maturation and experience (Fry & Hale, 2000).

According to Thorndike & Hagen (1996), fluid abilities differ from verbal and quantitative capacities in terms of necessitating problem solving abilities in novel situations, without using the knowledge gained in school or from previous experiences. The resolution of the presented problem is inferred from the problem situation given at that moment, not from conceptual or existent information. In addition, it is widely accepted in the literature that executive functions become more activated when the individual faces novel organizations rather than well-known situations (Shallice 1990, Walsh, 1998; as cited in Anderson, 2001). More specifically, executive functioning demands management of distracters, reasoning, regulation of attention, memory and other cognitive processes in the face of unfamiliar stimuli (Anderson, 2001). In that sense, fluid intelligence concept is considered to be one of the basic constructs that is related to executive abilities (Unsworth et al., 2009; Zook, Davalos, DeLosh & Davis, 2004).

Working Memory and Fluid Intelligence

Fluid intelligence refers to abstraction, reasoning, manipulation and adaptation abilities in the case of novel stimuli, especially figural and nonverbal symbols (Cattell, 1963; Horn & Cattell, 1966). On the other hand, working memory capacity necessitates the storage and manipulation of information while dealing with interfering stimuli in complex situations (Engle et al., 1999). Since both demanding the activation of reasoning, adaptation and abstraction capacities, these two concepts are expected to demonstrate correlations.

Studies in the literature regarding the relations between working memory and fluid intelligence cover discrepant arguments. Many authors suggest that working memory and fluid intelligence abilities refer to the same construct due to very high correlations between the measures of these concepts (Kyllonen & Christal, 1990; as cited in Bimey, Bowman & Pallier, 2006). For instance, Blair (2006) claims that these two concepts as well as executive functions could be labeled as one single concept called “fluid cognition” which basically includes inhibition of interfering stimuli and organization of actions serving for goal-attainment.

On the other side, some authors oppose to these arguments defending the fractionation of working memory and fluid intelligence as well as executive functions (Burgess, Braver & Gray, 2006; Garlick & Sejnowski, 2006; Heitz et al., 2006). For example, Ackerman, Beier & Boyle (2005) state that working memory, fluid intelligence and executive abilities demonstrate modest correlations accounting for 20-30 % of the variance that necessitate shared underlying properties, which cannot be sufficient to form a single construct. Moreover, Kane, Hambrick & Conway (2005) agree with the idea of non-isomorphic constructs; however, they suggest that the relations between these two concepts are much more higher, sharing 50 % of the variance. Overall, most of the studies in the literature support the idea that working memory and fluid intelligence capacities are related but distinct mechanisms (Conway, Kane & Engle, 2003; Engle et al.,1999).

The underlying constructs that explain positive correlations between working memory and general fluid intelligence abilities are on debate. The first argument accounting for the shared variance between these two constructs depends on “short-term memory” concept. For instance, some authors suggest that the predictor power of working memory on fluid intelligence decreases after the effect of short-term memory is controlled (Colom, Flores-Mendoza, Quiroga & Privado, 2005; Colom, Rubio, Shih & Santacreu, 2006; Colom, Abad, Quiroga, Shih & Flores-Mendoza, 2008). That is to say; short-term memory construct (i.e. storage) explains a huge part of the working memory concept which refers to the link between fluid intelligence and working memory as well.

For the second argument, in the 1999 study, Engle and his colleagues investigated the associations between short-term memory, working memory and fluid intelligence. Results of this study demonstrated significant correlations between working memory and fluid intelligence; however, short-term memory construct did not reveal any significant relationships. In the light of these findings, Engle et al. (1999) suggest that the linkage point between working memory and fluid intelligence concepts is “controlled attention”, not short-term memory. The authors also argue that the controlled attention responsible for the relation between working memory and fluid intelligence refers to the “central executive” component of the working memory. This way of look gains more support from the literature (Conway et al., 2003; Kane et al., 2005; Miyake, Friedman, Rettinger, Shah & Hergarty, 2001). This body of literature emphasizes the importance of sustained and controlled attention combating against distraction or interference to be the responsible construct for the association between fluid intelligence and working memory, not merely a storage capacity (Engle et al., 1999).

There are also studies suggesting the rethinking of the responsibility of the central executive despite of previously defending its contribution (Oberauer, Lange & Engle, 2004). For instance, Verguts & De Boeck (2002) suggest that the underlying linkage between working memory and fluid intelligence abilities depends on the ability to reuse problem solving strategies in a current task which were acquired in the previous task that demands similar solutions. As a result, the underlying construct explaining the bond between fluid intelligence and working memory necessitates more scientific research to reach clearer results. Nevertheless, neuroimaging studies provide some agreed evidence for the link between fluid intelligence and working memory accounting for the prefrontal cortex activation, as in the case of executive functions (Conway et al., 2003; Engle et al, 1999; Gray, Chabris & Braver, 2003; Kane et al., 2005; Parkin & Java, 1999).

Assessment of Executive Functions

Traditional Executive Functioning Assessment

Neuropsychology literature consists of several testing instruments aiming to assess executive abilities. These tests are mostly conducted in structured clinical settings under the supervision of an experimenter. However, especially regarding extensive cognitive skills such as executive functions, it becomes more complicated to find proper assessment tools and procedures capturing all aspects of this phenomenon. For instance, Parker & Crawford (1992) suggest that despite of the high amount of assessment tools, there exist very few amounts of tests which assess executive abilities on a valid and reliable basis.

Above all other testing tools, the Wisconsin Card Sorting Test (WCST) is considered to be one of the most reliable cognitive measures in executive functioning assessment (Anderson, 2001; Greeve, Stickle, Love, Bianchini & Standford, 2005). For this reason, this study depends on the WCST in order to capture executive abilities.

The Wisconsin Card Sorting Test (WCST)

The Wisconsin Card Sorting Test was first presented to the neuropsychology literature by Berg (1948). Following studies revised the original test and the latest version was generated by Heaton (1981). Studies indicate that the WCST is a frequently used measure in the assessment of executive functions (Anderson, 2001; Goldberg & Podell, 2000; Greeve et al., 2005).

The WCST was created by Berg (1948) to assess “abstraction” and “set shifting” abilities. Now, it is widely accepted that the WCST measures some other frontal lobe capacities; such as attention, conceptual thinking, perseveration, cognitive flexibility and working memory (Barcelo, Sanz, Volina & Rubia, 1997; Hartman, Bolton & Fehnel, 2001; Heaton, 1981). Moreover, the WCST is also determined to assess the ability to benefit from feedback and shifting strategies in response to environmental demand (Chaytor, 2004; Heaton, Chelune, Talley, Kay& Curtiss, 1993; as cited in S.C. Heaton et. al., 2002).

Since, the WCST was generated to use in adult samples, adaptation studies were carried out for the WCST to make it applicable for children sample as well. Chelune and Baer (1986; as cited Franzen, 2000) conducted a preliminary adaptation study of the WCST with 6- to 12-year-old children. This study indicated that children start to demonstrate adult level performances at the age of 10. Following scholars developed normalization studies. For instance, in the 1993 study of Roselli and Ardila, developmental norms for Colombian children with an age range of 5 to 12 were established. Results of this study indicate that test performances of children were closer to adult level by the age of 11-12. In addition, Shu, Tien, Lung & Chang (2000) carried out a norm study with 6- to 11-year-old children in Taiwan. This study also shows that children's cognitive potentials do not come closer to adult capacities before the age of 10-12. A study concerning developmental norms of the WCST was carried out in Turkey by Erol, Akçakın, Aközel, Dikmeer & Irak (2007) which also suggests similar developmental effects on the WCST as presented in the previous literature.

Above all, perseverative responses performance is one of the chief scores in the WCST used diagnostically to detect impairments (Heaton, 1981; Lezak, 1995). Briefly, perseverative responses refer to incorrect matches that occur due to the persistence in sorting according to the previous category, which demonstrates the inability to benefit from feedback as well. Additionally, two other most widely used scores of the WCST are completed categories and total errors which demonstrate number of successfully achieved categories and number of wrong or totally irrelevant matches, respectively (Bujoreanu, 2007).

The WCST has different kinds of administration protocols; such as short card version (WCST-64), standard card version and computerized protocols of both short and standard versions. In this study, the computerized version of the standard test (The

WCST: CV4), developed by Heaton (1981), was applied. Tien et al. (1996) indicated no statistical difference between manual and computerized versions of the test in a psychiatric sample regarding perseverative responses, perseverative errors and set breaks. These colleagues suggest that the computerized version of the WCST was more reliable due to eliminating experimenter errors (i.e. mistaken scoring, giving wrong feedbacks) and providing opportunities to obtain qualitative data (i.e. observation) as well. Conversely, Feldstein et al. (1999) suggest that there are differences on performances regarding standard and computerized versions of the WCST, and new norms should be generated for the computerized one. Furthermore, Artiola I Fortuny and Heaton (1996; as cited in Franzen, 2000) demonstrated that there were no performance differences between these two kinds of protocols, *for normal samples*. Beside these, in the 1995 study, Ozonoff demonstrated that computerized version of the WCST was more advantageous for children with autism than the standard WCST protocol due to leaving out social interaction factors. Overall, neuropsychology literature consists of studies supporting the use computerized tests (Butcher, Perry & Atlis, 2000; Luciana, 2003).

Despite of being the primary assessment procedure in clinical neuropsychology literature, traditional measures of cognitive skills, particularly executive functions, might possess some limitations covered under ecological validity issues. These limitations will be specifically reviewed in the following section.

Limitations of Traditional Assessment Procedures: Ecological Validity Issues

In its broad context, ecological validity refers to the degree of fitting of the performance found in experimental conditions into real life situations (Barkley, 1991; Burgess et al., 2006; Price, Joschko & Kerns, 2003; Silver, 2000). In its statistical mean, ecological validity gives information about the correlation between the data gathered in controlled experimental contexts and the measurement in daily life functionality (Chaytor & Schmitter-Edgecombe, 2003; Nadolne & Stringer, 2001; Silver, 2000). Due to some research concerns, many scholars suggest that it may lead into mistakes to assume that a measurement tool presenting healthy diagnostic results in laboratory or clinical contexts is also an ecologically valid instrument (Burgess, Alderman, Evans, Emslie & Wilson, 1998; Chaytor & Schmitter-Edgecombe, 2003). For instance, studies suggest that traditional neuropsychological tests account for only 18 to 20 % of the daily-life executive functionality (Chaytor, Schmitter-Edgecombe & Burr, 2006). In line with these suggestions, some of the considerations about ecological validity studies will be briefly mentioned below.

Burgess and his colleagues (1998) state that assessment procedures of cognitive functions in structured environments assume that the individual will face difficulties in real-life situations which require the functionality of the evaluated domain, in the case of presenting lower performances on a specific testing instrument. Authors suggest that this prediction might lead into some methodological drawbacks, especially when concepts like executive functions are taken into account. As widely accepted, executive functions are composed of multiple subcomponents that are captured under an umbrella construct. On the other hand, there are still controversies about the specific definition of the related constructs. In that sense, an instrument which claims to measure executive functions might in fact assess some subcomponents of the phenomenon such as inhibition or shifting. To avoid this situation, assessment tools need to be well defined in terms of specific components that they suggest to measure. Moreover, many instruments need to be applied in order to evaluate precisely all subcomponents of a cognitive process (Price et al., 2003). Especially in the assessment of executive functions, these considerations appear to be very important; however, they seem to be impractical in terms of applicability, due to time limitations or finding suitable assessment tools, especially for small scale studies.

As Chaytor and Schmitter-Edgecombe (2003) emphasize, there are main points in neuropsychological assessment procedures that should be taken into account before reaching exact decisions. In other words, factors expanding the gap between traditional neuropsychological assessments and daily-life evaluations should be considered especially for the sake of ecologically valid assessments.

Firstly, "testing environment" is suggested to be considered in order to clear ecological concerns. Laboratory measures aim to find out the best performance of the individual by providing isolated environments. However, results obtained in such an environment might not reflect what the individual actually does in real life-situations. Since functions are assessed in very structured testing environments, and activities like the initiation and maintenance of a given task are not up to the participant, executive functions particularly seem to demand the investigation of their ecological validity (Chaytor & Schmitter-Edgecombe, 2003; Manchester et al., 2004; Silver, 2000). Ecological medium is full of distracters and the elimination of these distracters while performing a work is mostly up to the individual. Additionally, most of the tasks in real life require the initiation and regulation of the individual itself.

Another point that should be considered is "the sample of behavior" that refers to the diversity of a behavior in terms of time and occasions. For instance, tasks are carried out for relatively shorter times and in specific occasions in traditional assessment procedures whereas daily-life requires maintaining tasks for longer periods and in multi-situations (Chaytor & Schmitter-Edgecombe, 2003). Thus, traditional assessments are considered to take a snapshot of the behavior with less generalization.

Another factor that needs to be kept in mind in ecological validity studies is the use of "compensatory strategies" in order to overcome cognitive difficulties (Long & Kibby, 1995; as cited in Chaytor & Schmitter-Edgecombe, 2003; Chaytor et al., 2006). For instance, one can use compensatory solutions in order to function more effectively in naturalistic environments (i.e. in the case of memory and organization problems, using agendas, etc.) which are not allowed in testing situations. In that sense, traditional neuropsychological test results are regarded to be an underestimation of the individual's real functionality (Long, 1996; as cited in Chaytor & Schmitter-Edgecombe, 2003). Conversely, one can maintain the use of compensatory strategies in testing procedures (e.g. semantic clustering, chunking) for limited times despite being able to prolong these strategies in daily-life for longer time periods. Thus, despite of being rarer, results obtained by the traditional assessment ways could also be an overestimation of the exact functionality of the individual (Chaytor & Schmitter-Edgecombe, 2003).

Finally, “non-cognitive factors” referring to emotional, physical and behavioral difficulties connected to the cerebral problems as well as pre-morbid functionality and environmental requirements should be considered in order to reach ecologically valid conclusions in neuropsychological assessments (Chaytor & Schmitter-Edgecombe, 2003).

Franzen and Wilhelm (1996; as cited in Chaytor & Schmitter-Edgecombe, 2003) suggest two classifications concerning ecological validity of testing tools. One of these approaches is “verisimilitude” formulation referring to the level of theoretical likeness of cognitive requirements of a structured test to cognitive requirements of naturalistic environments. Tests related to this approach simulate commonly-used everyday tasks to assess daily-life cognitive abilities manifested in behaviors rather than detecting impairments or differentiating normal populations from clinical samples. This formulation directly corresponds to generating new instruments based on ecological validity concerns (e.g. Test of Everyday Attention, Behavioral Assessment of the Dysexecutive Syndrome). Moreover, these concerns require revision of existent cognitive measures in terms of ecological interests. New assessment tools developed according to this approach are structured tests in which cognitive functions are assessed by asking for performing daily-life tasks in a laboratory.

The idea of carrying daily life functions into laboratory environment might lead to some empirical drawbacks. In that sense, some other instruments are needed as complementary forces in terms of making more comprehensive assessments of cognitive constructs. However, it is crucial to determine the behaviors to examine, the way to assess that behavior such as using clinician ratings or family members’ evaluations (Chaytor & Schmitter-Edgecombe, 2003). The other approach regarding the ecological validity phenomenon is the "veridicality approach" which indicates the degree of correlations between present assessment tools and measures of real life functionality (Franzen & Wilhelm, 1996; as cited in Chaytor & Schmitter-Edgecombe, 2003). This refers to the statistical computations in order to define ecological validity of existent measures. Since this study uses single tools to assess the correlations between lab-based instruments and behavioral measures, it is preferred to name ecological validity concerns as *behavioral correlates* of executive functioning. By this account, this study investigates the behavioral correlates of the Wisconsin Card Sorting Test (WCST) through an assessment tool that is known to measure everyday executive functionality of individuals.

In the 2008 study, Schwarz focuses on the fewness of research aiming to evidence the ecological validity of executive function assessment tools in real-life situations. She states that laboratory-based executive function tests could sometimes be effective in discriminating clinical populations and normal groups as well as different clinical samples. However, she further claims that these kinds of executive function measures demonstrate more invalid results than inventory type executive function tools when they are applied to particularly normal participants. Moreover, she proposes that tests like the WCST are successful in determining cognitive impairments; however, mostly they are not good at differentiating normal profiles in terms of functionality or skill usage.

Clinical neuropsychology literature consists of a plethora of studies focusing on ecological manifestations of executive functions (Barkley, 1991; Chaytor et al., 2006;

Chaytor, Temkin, Machamer & Dikmen, 2007; Farias, Harrell, Neumann & Houtz, 2003; Gioia & Isquith, 2004; Kibby, Schmitter-Edgecombe & Long, 1998; Odhuba, Broek & Jones, 2005; Price et al., 2003; Ready, Stierman & Paulsen, 2001; Wood & Liossi, 2006). Research intended to investigate the ecological validity of executive functions are widely conducted in adult samples (Silver, 2000). Research aim to discover the relations between laboratory-based measures and daily-life assessments in adult samples relatively indicate significant correlations (Kibby et al., 1998; Ready et al., 2001; Vriezen & Pigott, 2002). For example, in a study of Burgess et al. (1998) a battery of executive function measures were applied to dysexecutive syndrome patients, and their relatives or careers were asked to fill a rating tool regarding executive functions (i.e. the Dysexecutive Questionnarie). Results indicated that all executive function tests were significantly related to daily life ratings (range r=29, p<.05 to r=.40, p<.001).

Moreover, Chaytor et al. (2006) tested the ecological validity of several renowned executive functioning instruments, such as the Wisconsin Card Sorting Test (WCST), Trial Making Test, Stroop Test, and Controlled Oral Word Association Test, on a clinical sample. They also applied assessment tools developed in order to measure everyday behavioral manifestations of executive functions, namely Brock Adaptive Functioning Questionnaire (BAFQ) and Dysexecutive Questionnaire (DEX). The results of this study demonstrate low correlations between traditional executive functioning tests and naturalistic materials dealing with daily-life performances. For example, only Stroop Color-Word Test displayed significant correlations with DEX (r=.35, p< .05) among all other executive functioning tests included in this study.

Moreover, the WCST or Controlled Oral-Word Association Test scores failed to reach significant correlations with each of the aforementioned daily-life performance tests.

Recent studies utilize evaluation instruments for gathering information related to the daily-life reflections of executive functions in *children* (Anderson & Doyle, 2004; Burmeister et al., 2005; Hartshorne, Nicholas, Grialou & Russ, 2007; Kral et al., 2003; Mangeot et al., 2002; Shonfeld, Paley, Frankel & O'Conner, 2006). It is mostly observed that the knowledge of people, having the opportunity to observe the individual for longer times, is asked by instruments tapping the individual's daily-life functionality (Gioia, Isquith, Retzlaff & Epsy, 2002; Mahone et al., 2002; Shear, DelBello, Rosengerg & Strakowski, 2002). In line with this aim, children-based studies focus on the evaluations of parents and teachers since they have the opportunity to observe children at home and school environments for longer period of times (Conners, Sitarenios, Parker & Epstein, 1998; Goyette, Conners & Ulrich, 1978; Schachar, 1986; Thorell & Nyberg, 2008).

Research indicate low to moderate correlations between child instruments measuring executive functions in laboratory and tools assessing the functionality in daily life (Barkley, 1991; Bodnar, Prahme, Cutting, Denckla & Mahone, 2007; Brewis, 2002; Chaytor & Schmitter-Edgecombe, 2003; McGee, Clark & Symons, 2000; Vriezen & Pigott, 2002). For instance, in a study of Vriezen and Pigott (2002), the relationship between the Wisconsin Card Sorting Test (WCST) and the Behavior Rating Inventory of Executive Functions (BRIEF) was investigated as well as several other well-known executive function instruments (e.g. Trail Making Test). Results indicate that the BRIEF did not show any correlations with laboratory-based tests of executive functions. Moreover, Bodnar et al. (2007) examined the relations between a group of computerized measures of inhibitory control and the BRIEF ratings. This study demonstrated marginally significant correlations between these two classes of tools. Overall, ecological validity issues become more important for children studies due to lower predictive values of cognitive assessments on daily-life functionality.

Executive functionality is regarded as a main topic in ecological validity studies because of their reputation on revealing poor relations between laboratory and real setting assessments, thus, having poor ecological validity (Chaytor & Schmitter-Edgecombe, 2003). Overall, it might be useful to take into account ecological concerns while deciding on an individual's use of existent cognitive capabilities, specifically executive ones. This notion necessitates being informed related to the daily-life implications of executive functions as well as laboratory-based evaluations. In accordance with this opinion, it is required to utilize instruments providing a global knowledge about the individual's executive functions in its ecological medium (Bodnar et al., 2007).

Behavioral Measures of Executive Functions

As indicated in the previous section, traditional assessment procedures of executive functioning necessitate the use of behavioral measures for the sake of comprehensive evaluations. Child neuropsychology literature consists of several behavioral measures such as Conners' Rating Scales (Conners, Starenios, Parker & Epstein, 1997; Conners et al., 1998) or Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2007) that aim to provide information depending on the evaluations of people (e.g. parents and teachers) who could observe the child's behaviors for longer durations and in different contexts. Besides parent and teacher evaluations, there are also several self-report measures used as behavioral rating instruments to evaluate performances of individuals in naturalistic environments.

Despite of being frequently used in the literature, none of these testing tools *specifically* address executive functioning abilities; they rather give global information about general behavioral patterns of the individuals. One of the measures tapping this issue is the Children's Executive Functions Scale (CEFS; Silver et al., 1993 as cited in Goulden & Silver, 2009), a 99-items *parent scale* capturing five different executive domains. On the other hand, the most frequently used instrument in this realm is The Behavior Rating Inventory of Executive Functions (BRIEF; Gioia, Isquith, Guy & Kenworthy, 2000) including 86 items that capture executive abilities in a wide range with eight sub-domains and three index scores. However, within the scope of this research, a relatively new testing instrument, The Childhood Executive Functioning Inventory (CHEXI; Thorell & Nyberg, 2008) will be utilized in order to investigate executive functioning abilities of school-aged children in daily-life.

<u>The Childhood Executive Functioning Inventory (CHEXI)</u>

The Childhood Executive Functioning Inventory, developed by Thorell & Nyberg (2008), gives information about parent and teacher evaluations concerning behavioral manifestations of *specifically* executive functions, in children between the ages of 4 and 7.

The primary study about the CHEXI was conducted by Thorell & Nyberg (2008) among 130, 4- to 7-year-old Swedish kindergarten students. These students were examined via a series of tests (e.g. go-no-go paradigm, word span task, etc.) in order to obtain information about their executive functioning abilities. Moreover, 114 (88%) were evaluated via the CHEXI by their parents and 105 (81%) were assessed by their teachers. Results of this study indicated that the CHEXI consists of two subscales such as Working Memory and Inhibition, which demonstrate good psychometric qualities. Additionally, it was shown that the CHEXI was significantly related with the cognitive measures of these two constructs.

The second study of the CHEXI was carried out by Thorell, Eninger, Brocki & Bohlin (in press) including children at risk for ADHD and normal controls. Results of this study indicated that the CHEXI was a successful measure in discriminating children with ADHD from non-ADHD groups. Findings of this study also demonstrated that the CHEXI is a proper measure to identify children at risk of executive difficulties (i.e. ADHD), which allows for earlier intervention and prevention strategies.

The Childhood Executive Functioning Inventory theoretically stems from Barkley's "Hybrid Model" (2005) that regards inhibition, working memory and regulation processes as core constructs of executive functions. In addition to this theoretical base, researchers refer to Baddeley and Hitch's (1974) "Working Memory Model" in the generation of items related to working memory. As previously mentioned, this model emphasizes information storage and processing concepts, and regards these properties as principal components generating working memory construct.

The inventory was reported to enclose behaviors of the child in terms of executive functions rather than being a replacement for lab-based executive functions tests (Thorell & Nyberg, 2008). In that sense, the CHEXI can be regarded as an alternative measure for executive functions that can be used to get information about executive functionality of children in naturalistic environments (i.e. school or home). Besides, Thorell & Nyberg (2008) suggest that these kinds of rating materials are advantageous for their practical use. Additionally, authors mention that rating materials can be used as screening instruments in order determine children at risk for developing problems. Overall, a comprehensive knowledge about executive functioning abilities could be obtained in the case of using lab-based tests and inventories in combination (Thorell et al., in press).

Limitations of Behavioral Measures

Informant ratings are the most frequent way of supportive assessment; however, this kind of assessment procedures also possesses some limitations. For instance, studies often demonstrate that the most basic sources in the evaluation of children's behavior do not always agree on the current functioning of the individual (Achenbach, McConaughy & Howell, 1987; De Los Reyes & Kazdin, 2005; DuPaul & Barkley, 1992; McGee et al., 2000; Schonfeld, Paley, Frankel & O'Conner, 2006).

There are most widely accepted reasons that could explain discrepant evaluations. Primarily, the different settings such as school or home might give different information to raters due to their different natures (Achenbach et al., 1987; McCandless & O'Laughlin, 2007; Muir-Broaddus, Rosenstein, Medina & Soderberg, 2002). School and home environments generally possess different stimuli and demand different responses. As widely accepted, academic environment require proper executive abilities from being able to sit on a desk without being fidgety to concentrating on tasks to complete assignments in order to attain goals, which basically require inhibition and working memory abilities. Most of the time, the school setting asks children to regulate the execution of tasks as well as themselves individually due to child-teacher ratio. Besides, for younger children, home environment often necessitates less compelling planning and sequencing abilities such as preparing required equipments for the school or dressing on their own without reminders. Additionally, home environment contains auxiliary executive agents (e.g. mothers, child minders) enabling more one-to one executive function support (Anderson, 2002).

One of the other limitations of behavioral measures depends on the specificity issues. Behavioral measures *generally* do not tap lower-level abilities, and provide broader information about the functionality of the individual (Anderson, 2002; Thorell & Nyberg, 2008), which might also be a disadvantage from another perspective. This property could also be interpreted as a lack of detecting specific abilities. However, it is better to keep in mind that issues of specificity are also problematic in cognitive procedures regarding extensive skills such as executive functioning (Bennett, Ong & Ponsford, 2005).

Moreover, behavioral measures might lack to reflect specific skills, especially for younger children, despite of being cognitively acquired. For instance, in their longitudinal study, Riggs, Blair & Greenberg (2003) demonstrated that children in younger ages acquire executive capacities on a cognitive level; however, it might last a couple of years to accurately integrate these skills in daily life. In the aforementioned study, cognitively acquired skills were not manifested in behavioral tools at the time of cognitive assessment; however, these assessments predicted behavioral evaluations over a two year period. Moreover, Gathercole & Baddeley (1993) suggest that before the age of six, children show quantitative changes on a cognitive level; however, these changes are not fully detected in qualitative fashions.

Cognitive and behavioral procedures in executive functioning possess several different characteristics. As a more assertive argument, studies also suggest that behavioral and cognitive measures of executive functioning depend on different frontal regions; cognitive measures are captured by dorsolateral areas whereas behavioral measures are relied on orbito-frontal areas (V. Anderson, P.Anderson, Northam, Jacobs & Mikiewicz, 2002).

As widely accepted, precise and reliable clinical evaluations require comprehensive assessment procedures (Achenbach, 2006; Anderson et al., 2002; Goulden & Silver, 2009; Mahone et al., 2002; Mangeot et al., 2002; Silver, 2000). In that sense, none of these assessment procedures could be excluded in order to conduct healthier studies in the clinical neuropsychology realm. That is to say, a holistic way of look might be more informative, including both cognitive procedures and behavioral assessments obtained from both home and school environments.

Aims of the Study

The first aim of the study was to conduct a validation study for the Turkish version of the Childhood Executive Functioning Inventory (CHEXI) among first and second grade students. Secondly, it is aimed to examine the associations between the Wisconsin Card Sorting Test (WCST) and the CHEXI. Furthermore, it is also purposed to define the cognitive capacities captured by the WCST. Moreover, it is aimed to carry out analyses between basic cognitive constructs such as executive functioning, working memory and fluid intelligence in order to obtain developmental knowledge regarding these abilities in early-school aged children. Finally, the effects of demographic variables (e.g. gender, grade) on executive functions, working memory and fluid intelligence abilities are aimed to be determined. Overall, this study intends to capture executive functioning from different aspects (i.e. cognitive and behavioral) in order to conduct comprehensive evaluations.

Research Statements

In the light of aforementioned purposes, this study aimed to explore:

1. The factorial structure of the CHEXI Parent and CHEXI Teacher
2. The factorial structure of the WCST

Based on theory and prior research, the following hypotheses are proposed:

Hypothesis 1: If the CHEXI is a behavioral correlate of the WCST, then the scores of the WCST will show significant correlations with the CHEXI scores.

Hypothesis 1a: If inhibition factor is obtained in the CHEXI, then perseveration related scores of the WCST will correlate with inhibition scores of the CHEXI.

Hypothesis 1b: If the WCST captures executive abilities extensively, then the WCST scores will also correlate with working memory scores of the CHEXI.

Hypothesis 1c: If working memory factor is obtained in the CHEXI, then working memory scores of the CHEXI will correlate with DST Backwards scores.

Hypothesis 1d: If CogAT® Nonverbal Battery captures novel problem solving abilities, then working memory scores of the CHEXI will correlate with CogAT® Nonverbal Battery scores.

Hypothesis 2: If the WCST and CogAT® Nonverbal Battery assess nonverbal reasoning abilities, then there will be significant correlations between the scores obtained from these two instruments.

Hypothesis 3: If the WCST captures executive abilities extensively, then the WCST will also correlate with Digit Span Backwards scores.

Hypothesis 4: If both CogAT® Nonverbal Battery and Digit Span Backwards capture novel problem solving abilities, then there will be significant correlations between the scores obtained from these two instruments.

The study will also explore the effects of demographic variables (e.g. gender, grade) on the CHEXI, the WCST, Digit Span Backwards and CogAT® Nonverbal Battery performances of children.

CHAPTER 2

METHODS

Participants

The child participants of the study were one hundred and thirty-two first (n=70) and second (n=62) grade students recruited from 11(7 public and 4 private) primary schools in diverse regions of Istanbul. The mean age of these participants was 6 years and 11 months, ranging from 5 years and 10 months to 8 years and 4 months. The sample included 73 females and 59 males. One hundred and four of the child participants were right-handed whereas 12 of the participants were left-handed, and 4 students in the overall sample were mixed-handed. The sample did not include any neurologically diagnosed children, depending on parent and teacher declarations.

The parents (or family members) and class teachers of the child participants were also included in the study. One hundred and thirty four parents agreed to fill out the required materials. Besides this, 36 class teachers accepted to participate in the study.

Instruments

Demographic Information Form

This form asks for the person (e.g. mother, father, etc.) filling out the test; the child participant's gender, date of birth, number of siblings, birth order, preschool education and medication history. Moreover, the form includes questions about maternal and paternal occupations, employment status and employment length in addition to their educational levels. This form was filled out by the family members of the child. This form was prepared by the researcher. A copy of the material can be seen in the Appendix A.

Teachers' Ratings of Children's Academic Performance

Teachers were requested to respond to an additional question asking them to rate each child's overall academic performance in comparison to his/her class-mates in the latest semester. Ratings were based on an eight-point Likert-type evaluation ranked as follows: 0 "I do not have enough information", 1 "the worst in the group", 2 "better than the worst", 3 "much better than the worst", 4 "average", 5 "better than the average", 6 "much better than the average" and 7 "the best in the group". This academic performance assessment technique was adapted from the 1993 study of Roselli and Ardila.

The Childhood Executive Functioning Inventory (CHEXI)

The Childhood Executive Functioning Inventory (Thorell & Nyberg, 2008) consists of 26 items. Initially, the items of the CHEXI were categorized into four *a priori* subscales. Eleven items were considered to be under the "*working memory*" subscale (e.g. "24.Has difficulty keeping things in mind while s/he is doing something else"). Four items were regarded to be related to the "*planning*" subscale (e.g. "20.Has difficulty with tasks or activities that involve several steps"). Six items were considered to be associated with the "*inhibition*" subscale (e.g."13.Has difficulty holding back his/her activity despite being told to do so"). And finally, the last subscale named *"regulation"* included five items (e.g. "2.Seldom seems to be able to motivate him-/herself to do something that s/he doesn't want to do").

The inventory asks participants to state how correctly each item defines the child/student. Ratings are as follows: (1) Definitely not true (2) Not true (3) Partially true (4) True and (5) Definitely true. The higher scores an individual gets in the inventory, the more difficulty concerning executive functions are regarded to occur. The inventory does not include any reverse items. Scores are obtained via summing the rate one gets for each item.

Regarding test-retest reliability, 30 *parents* were randomly selected in order to fill out the CHEXI with an interval of 3 weeks average, ranging between 2 to 4 weeks. Test-retest reliability score of the CHEXI was found .89 (p<.001). Additionally, test-retest reliability coefficients for a priori subscales were found to be as follows: (1) the inhibition subscale, .86 (2) regulation subscale, .84 (3) working memory subscale, .75 (4) planning subscale, .94 (Thorell & Nyberg, 2008).

As mentioned above, in the first step, the CHEXI was divided into four subcomponents as (1) working memory (2) planning (3) inhibition (4) regulation. However, factor analytic results revealed loadings on two factors: (1) *working memory* and (2) *inhibition*. The first factor involved items of working memory and planning. The second factor included items regarding inhibition and regulation subscales. Overall, these two factor structure explained 41.2 % of the variance. Additionally, the correlation between these two factors was .65. All of these computations were conducted among the CHEXI *parent* ratings (Thorell & Nyberg, 2008).

Further analyses were carried out in order to determine the factor structure of the CHEXI. The replication study among *teachers* revealed two factor solutions as well, accounting for 67 % of the variance. In addition, the correlation between two factors was found .69, in teacher evaluations. Lastly, the correlations between parent and teacher ratings in terms of two factors were significant (WM: r=.32, p<.01; I: r=.38, p<.001) (Thorell & Nyberg, 2008).

The translation of the CHEXI into Turkish was conducted by a couple of advanced Turkish and English speakers and back-translations were done by another group of individuals who are also capable of these languages at an advanced level. As the following step, back-translations were compared with the English version of the CHEXI, and after a few of word editing, the final form of the Turkish version of the CHEXI was obtained.

The Wisconsin Card Sorting Test (WCST)

This study employed the computerized version of the WCST (the WCST: CV4) developed by Heaton (1981). The WCST (Berg, 1948; Heaton, 1981) consists of 4 stimulus cards and 128 (two sets of 64) response cards. Each card includes differently colored and numbered shapes. The shapes on the cards are pluses, circles, stars and triangles. Each card has minimum one, maximum four shapes. The colors of the shapes on the cards are red, green, blue and yellow. Each card is composed of different combinations regarding the aforementioned three properties. In this test, the participants are asked to match 128 response cards one by one with a stimulus card that is considered to be correct for the individual. The six right matching categories are color, shape, number, color, shape and number in order. The consecutive ten right matches in a category is the requirement of passing to the other category. A "right" or "wrong" feedback is given to the participant following his/her every matching response without any information about the right matching category. The participant is expected to find the right category according to feedbacks. Additionally, participants are considered to change the matching strategy when it leads to wrong sorting. The application is ended when the participant completes all of the six categories or uses all 128 response cards.

The scoring of the WCST is as follows: (1) trials administered (2) total number of errors (3) total number of correct responses (4) completed categories (5) perseverative responses (6) perseverative errors (7) percent perseverative errors (8) non-perseverative errors (9) trials-to-complete-the 1st category (10) conceptual level responses (11) percent conceptual level response (12) failure to maintain set (13) learning to learn.

There exists several studies related to psychometric qualities of the WCST; within the scope of the current research, some of them will be reviewed. For instance, Lin, Chen, Yang, Hsiao & Tien (2002) conducted a study in an adolescent sample and revealed three factor structures as “overall conceptualization/ problem solving”, “learning” and “inefficient sorting”, accounting for 88% of the variance. Additionally, Yeniçeri & Atalay (2008) carried out an internal validity study of the WCST with 8- to 11-year-old Turkish children, and revealed three factors as “conceptual thinking”, “perseveration” and “set maintenance”.

Moreover, Greve, Ingram & Bianchini (1998) conducted a study with clinically diagnosed patients to analyze the factor structure of the WCST. Results defined three factors on the WCST, such as “concept formation/perseveration”, “failure to maintain set” and “non-perseverative errors”. Non-perseverative errors was proposed to be a new factor as an addition to the results of the previous factor analytic studies of the WCST

(Goldman et al., 1996; Greve et al., 1997; Paolo et al.,1995; and Sullivan et al., 1993; as cited in Greve et al., 1998). Moreover, in the 1998 study, Koren et al. examined the factor structure of the WCST on a sample of schizophrenic patients. This study revealed three factors such as "perseveration", "failure to maintain set" and "idiosyncratic sorting", the latter one with a strong discriminatory power among schizophrenic patients and normal controls. Furthermore, Greve, Bianchini, Hartley & Adams (1999) replicated their previous study on a sample of patients getting stroke rehabilitation due to cerebrovascular impairments. Similar to the previous study (i.e., Greve et al., 1998) results revealed a three-factor structure as indicated above, accounting for 96.8 % of the variance.

In 2002, Greve, Love, Sherwin, Mathias, Ramzinski & Levy carried out another study on a traumatic brain injury sample in order to determine the factor structure of the WCST. The results of this study also confirmed previously mentioned three-factor solutions referring to "cognitive flexibility", "problem-solving" and "response maintenance" capacities. However, in the 2005 study, carried out with a huge group of mixed participants (e.g., psychiatrically, neurologically etc. impaired), Greve et al. determined that three factor model was not so strong unless taking into account the data of participants who use all of the 128 cards to complete the administration. Nevertheless, they credit for the first factor (as they later on call "general executive functioning") to indicate robust results in both ending types of the administration (i.e., either completing 6 categories or using all of the 128 cards).

The reliability of the WCST seems to be a bit problematic due to generating a potential for practice effect in consecutive administrations (Franzen, 2000). This risk is tried to be controlled by determining enough intervals between two administrations. In line with this issue, Tate, Perdices and Maggiotto (1998; as cited in Franzen, 2000) conducted a study on a traumatic brain injury sample (TBI) with an interval of 9 months. Results indicated that normal controls demonstrate similar results between two administrations; however, TBI sample display improved scores. Besides, the updated WCST manual (1993; as cited in Bujoreanu, 2007) demonstrates reliability scores ranging from 0.35 to 0.72. Additionally, Bowden et al. (1998) carried out a reliability study on colleague students and found similar results with the original WCST norms, indicating significant results for completed categories (r=.60, p<.05) and total errors (r=.51,p<.05). Moreover, the study of Axelrod, Goldman &Woodland (1992; as cited in Bujoreanu, 2007) indicates high inter-scorer and intra-scorer reliability for the WCST, in a range from 0.91 to 0.93. Finally, Lezak (1995) suggests that inter-scorer reliability of the WCST is .88 whereas intra-scorer reliability score is .96.

Digit Span Subtests (DST) of the Wechsler Intelligence Scale- Revised Version

The Digit Span subtest of the WISC-R (Wechsler, 1992/1994; as cited in Savaşır & Şahin, 1995) was used in the study as digit span tasks. Administration consists of two tasks that require the capacity to hold orally presented information in mind both relate to verbal memory abilities in general. Digit Span Forwards demands the participant to repeat after each digit serial in the same order as the examiner presents in a speed of one second per digit. Digit Span Backwards task necessitates repeating the given digit serial in the reverse order. This subtask particularly demands the capacity to hold the given information in mind and to manipulate it according to task demands which is considered to refer to working memory capacity (Brocki & Bohlin, 2004). The former subtask includes seven items with two trials ranging from three to nine digits sequentially. The latter subtask similarly consists of seven items with two trials;

however, items in this task range from two to eight digits. The participant gets two points in the case of repeating all digits correctly in both of the trials. The participant gains one point if s/he accomplishes only one trial. Both tasks are finalized when the participant fails to repeat each of the two trials of an item.

Standardization studies of the WISC-R in Turkish sample were conducted by Savaşır & Şahin (1995) among a large sample through several years. However, psychometric information about Digit Span subtest seems to be missing (Savaşır & Şahin, 1995). Kaufmann (1994) suggests that DST of the WISC-III indicates .85 split-half reliability, as well as .73 test-retest reliability.

The Cognitive Abilities Test/ Nonverbal Abilities Subscale (CogAT®)

The Cognitive Abilities Test Form 5 is a general ability test developed by Thorndike and Hagen (1996), and can be applied from kindergarten to twelfth grade students. The theoretical base of CogAT® depends on Cattell's (1963) fluid-crystallized (*gf-gc*) intelligence concepts as well as Vernon's (1961; as cited in Thorndike & Hagen, 1996) Hierarchical Model of Intelligence. Thorndike and Hagen (1996) suggest that CogAT® principally assesses general abstract reasoning abilities that determine general fluid reasoning (*gf)*.

The Cognitive Abilities Test consists of two chief batteries as follows: (1) The Primary Battery that can be applied from kindergarten to second grade students, and divided into two parts as first and second (2) The Multilevel Battery which can be utilized from third grade to twelfth, and includes different levels from A to H. Each of the two main batteries of CogAT® consists of three sub-batteries including Verbal, Qualitative and Nonverbal abilities subtests. Thus, four kind of scores are obtained by CogAT®: (1) verbal score (2) qualitative score (3) nonverbal score (4) total score.

Since this study included first and second grade students, the first level of the Primary Battery was utilized. Specifically, the Nonverbal Abilities Subtest of the Primary Battery Level-1 was administered in order to provide supportive information for a nonverbal test, namely the WCST, and to obtain a nonverbal *g* score.

The Nonverbal Abilities Subscale of CogAT® is divided into two subtests named the Figure Classification and Matrices. The Figure Classification subtest consists of three stimulus figures that have shared properties. Students are asked to choose one of the four response figures that can be clustered with aforementioned three in terms of their shared properties. On the other hand, Matrices Subtest contains items including four boxes. The above two boxes contain figures placed according to a logic; however, one of the below two boxes is empty. Examinees are expected to choose the best fit for the empty box among four choices by reading the cue of the above two matrices. Both subtests were scored via summing correct items. Each correct item was regarded as one point. The total CogAT® Nonverbal score was obtained by summing total scores of two subtests (i.e. figure classification and matrices).

Regarding psychometric qualities of CogAT®, Thorndike and Hagen (1996) present a .94 internal consistency coefficient for the first graders, also including .83 for verbal abilities, .88 for quantitative abilities and .91 for nonverbal abilities subtests. The construct validity of CogAT® was examined in Turkey by Alp & Diri (2003). Results of this study revealed a .97 internal consistency coefficient for overall CogAT®.

Internal consistency scores were .79 for verbal abilities, .97 for quantitative abilities, and .97 for nonverbal abilities subtests. Additionally, Alp & Diri (2003) studied predictive validity of CogAT® in association with grade averages among 177 first graders with three years interval. Results demonstrated that CogAT® total scores were significantly related with grade averages (r=.50, p<.001). That is, CogAT® was successful in predicting academic achievement three years later.

Procedure

The study was carried out in a group of schools located in different regions of Istanbul. The required permissions regarding The Republic of Turkey Ministry of National Education and Bogazici University Ethics Committee were obtained before starting the project. In the second step, contacts with school principals were arranged in order to explain the project, and get their consent to carry out the research in their schools.

The following step after defining consentient school principals was determining consentient class teachers. Teachers were informed about the study and their consents were obtained. After having consensus with class teachers, students were chosen in terms of performing below average, average and above average academically. This selection procedure was obligatory because if all students in the class were included in the study, it would be very hard for class teachers to rate all of them. In other words, parents were filling out required forms only for their own child, whereas, in that case, class teachers were required to complete questionnaires for all students in the class, which means at least 20 to 50 students. This was not possible for teachers, thus, maximum 5 or 6 students were chosen from each class according to the aforementioned criteria to partially overcome this limitation. Teachers were required to complete the CHEXI for each participating child. After completing the CHEXI, teachers were demanded to respond to an additional question asking them to rate each child's overall academic performance in the latest semester. This question was printed on the last page of the CHEXI teacher form. The completion of the CHEXI and academic evaluation question lasts for approximately 5 to 8 minutes.

In the following step, envelopes were sent to chosen first and second graders' parents including informed consents (see Appendix B) in order to ask for their own volunteer participation as well as permitting their child to join in the study. These envelopes also contained a demographic information form attached to the CHEXI-Parent. The CHEXIs and demographic information forms were sent with consent forms in order to avoid disorganization and loss of materials between transfers. The completion of the CHEXI and the demographic information questionnaire last for approximately 5 to 12 minutes. All parental accession process was conducted with the collaboration of class teachers.

Students, whose parents gave consent for their children, were informed about the study within age-appropriate limits and interests. In addition, they were orally asked to join in the study and only consentient ones were included.

The procedures regarding child assessments were twofold. In the first step, the Computerized Version of the Wisconsin Card Sorting Test (The WCST: CV4) was applied to children individually in a suitable testing place in his/her school during class hours, according to the WCST application protocols. After completing the WCST administration, children performed The Digit Span Forwards and Backwards tasks in the same session. The finalization of these tests took approximately 25 to 40 minutes which corresponds to a class hour. As the second step, the assessment of children was completed with the application of CogAT® Nonverbal Abilities Subtest. This test was applied in group sessions in the following days after the completion of all WCST and DST administrations in that school. Maximum 12 or 15 children were gathered together in a suitable place (e.g. class, library, etc.) to apply CogAT®/N. First of all, sample administrations were conducted together with children via following instructions aiming to inform children about the requirements of the administration. Regarding sample items, children were informed about the correct choice. After trial administrations, children were demanded to carry on the task without receiving any feedback about answers. The application of CogAT®/ N lasted for 30 to 40 minutes.

Data Analyses

First of all, this research aimed to investigate the internal structure of the CHEXI via factor analyses. In addition, the internal structure of the WCST was investigated with factor analyses. Moreover, Pearson Product Moment Correlations were conducted to determine the relationships between the CHEXI Parent, CHEXI Teacher, Working Memory and Inhibition Subscales of the CHEXI Parent and Teacher, the WCST scores, Digit Span tasks, and CogAT® scores. Furthermore, the effects of demographic variables on test scores were examined via using ANOVA and MANOVA techniques.

CHAPTER 3

RESULTS

The first part of this chapter includes information regarding basic characteristics of the sample. The first part also contains information related to descriptive statistics of test scores included in the study. The second part addresses the basic statements of the study referring to the exploration of internal structures of the CHEXI Parent and Teacher forms as well as the WCST. In order to fulfill this aim, factor analytic computations were performed. The third part of this chapter consists of the investigation of intercorrelations between test scores of the study as well as sub-dimensions obtained from factor analytic computations aiming to answer research hypotheses. Pearson Product Moment Correlations were run to address this issue. Finally, the last part of this chapter includes variance analyses in order to find out the effects of demographic variables on test scores.

Sample Characteristics

Before conducting analyses, the data was screened out for outliers. Data revealed outliers for the CHEXI and the WCST. Participants having standard scores greater than 3.29 ($p<.001$, two tailed) were regarded as outliers, and they were excluded from the sample (Tabachnick & Fidell, 2007). Thus, after the eliminations, there were 134 children evaluated by their parents, 129 of which were supported with teacher evaluations too. Additionally, 125 children were assessed via the WCST, 133 by Digit Span Tasks, and 93 were tested by CogAT® Nonverbal Battery.

The age of the participants[1] ranged from 5 years and 10 months to 8 years and 4 months, with a mean of 6 years,11 months ($M_{age\ total}^{2}$=83.37, SD=6.62). The sample was divided into two groups in terms of age; the first group as "6 years 11 months old and below" and the second one as "7-year- old and above" (see Table 1). The first group includes 5 (n = 2) and 6 years old children (n = 66), ages ranging between 5 years, 10 months and 6 years, 11 months ($M_{1^{st}\ age\ total}$ = 78.22, SD = 3.66). The second group contains 7(n= 60) and 8 (n = 4) years old children, ages ranging between 7 years and 8 years and 4 months ($M_{2^{nd}\ age\ total}$ = 88.85, SD = 4.21).

Regarding gender, 55% (n=73) of the participants were females and 45% (n= 59) of the participants were males. The percentage of the female participants in the first age group was 54 % (n=37) and the percentage of male participants was 46 % (n=31). In the second age group, female and male participants accounted for 56 % (n=36) and 44 % (n=28) of the sample, respectively. Cross tabulations in terms of age and gender are presented in Table 1.

Table 1

Cross Tabulations for Age and Gender

		Gender		
		Female	Male	Total
Age	6 years 11 months old and below (age total < 84.00)	37	31	68
	7-year-old and above (age total ≥ 84.00)	36	28	64
	Total	73	59	132

[1] These analyses were conducted among 132 participants who at least have a behavioral evaluation or cognitive assessment.
[2]Age total represents participants' ages in terms of months.

First grade students constituted 53 % (n=70) of the sample and second grade students accounted for 47 % (n=62). Grade variable was preferred to use interchangeably with age variable in some of the following analyses due to the high correlation between them ($r_s = .73$, $p < .01$).

Because of very poor rates of return, private school students were 25 % (n=33) of the sample. Thus, most of the sample, 75 % (n=99), were public school students. With regard to handedness[3], 87 % (n=104) of the participants were right-handed, 10 % (n=12) were left-handed and 3 % (n=4) were reported as mixed-handed. In terms of preschool education, most of the participants, 79 % (n=100), were reported to receive preschool education. Only, 21 % (n=27) of the participants did not receive any preschool education. Regarding medication histories, 80 % (n=102) of the sample were reported as not being on any kind of medication. Merely, 20 % (n=25) of them were reported to be on medication; however, any of the disorders were neurologically-based (e.g. asthma, allergy, ENT problems).

In terms of number of siblings, participants were categorized into three groups as "none siblings", "one sibling" and "two or more siblings". Above all, 36 % (n=46) of the sample were single child without any siblings sorted in the first sibling category, 50 % (n=63) of the participants had one sibling, and 14 % (n=18) had more than two

[3] There were 12 missing cases in terms of handedness, thus, these analyses were conducted among 120 participants. Additionally, there were five missing case in terms of preschool education, medication history, number of sibling, birth order. Thus, these computations were conducted on 127 participants. Similarly, due to missing data, analyses of paternal education levels were performed on 126 participants. Additionally, seven cases lacked maternal education level information, that is, analyses regarding this variable were conducted among 125 participants.

siblings. Regarding birth order, the sample was divided into three categories as “the first child”, “the second child” and “the third and later”. According to these categories, 60 % (n=76) of the sample were the first child, 29 % (n=37) of the children were the second one and 11 % (n=14) of them were the third child or later.

With regard to maternal and paternal education levels, the sample was divided into three categories. The first category was “low education” which refers to completing 8 year education and below. The second category was “middle education” representing a high-school diploma. And the third category named as “high education” indicated an undergraduate or graduate degree. Results indicated that 40 % (n=50) of mothers were sorted in the first education category, 31 % (n=39) in the second, and 29 % (n=36) were in the third category. Furthermore, 37 % (n=47) of the fathers were in low education category, 30 % (n=38) were in middle education category and 33 % (n=41) were in the high education category. In this study, maternal education levels were taken into account as a research concern due to the theoretical background and also satisfactory correlations between paternal and maternal education levels (r_s= 0.67, p < .01).

Statistical analyses were conducted via using raw scores. Descriptive statistics regarding the CHEXI Parent/Teacher Forms, the WCST, DSTs and CogAT®-Nonverbal Battery Figure Classification/Matrices Subtests scores are presented in Table 2.

Table 2

Descriptive Statistics: Minimum, Maximum Values, Means and Standard Deviations

The scores	*N*	Min	Max	M	*SD*
CHEXI-P	134	30.00	108.00	57.19	15.78
CHEXI-T	129	26.00	98.00	55.59	16.45
WCST-TA	125	79.00	128.00	121.96	12.50
WCST-TE	125	10.00	98.00	49.51	22.00
WCST-TC	125	30.00	103.00	72.45	16.30
WCST-CC	125	0.00	6.00	3.44	1.96
WCST-PR	125	4.00	91.00	29.31	17.18
WCST-PE	125	4.00	68.00	25.31	13.81
WCST-NPE	125	4.00	64.00	24.20	13.63
WCST-PPE	125	4.00	53.00	20.23	10.33
WCST-TC1st	125	10.00	129.00	36.60	33.95
WCST-CLR	125	3.00	99.00	57.36	22.31
WCST-PCLR	125	2.00	87.00	48.42	21.29
WCST-FMS	125	0.00	5.00	1.72	1.34
WCST-LL	103	-34.95	13.00	-4.28	10.39
DSF	133	0.00	7.00	3.93	1.51
DSB	133	0.00	7.00	2.92	1.62
DST	133	0.00	13.00	6.86	2.71
COGAT®-FC	93	3.00	20.00	10.77	3.85
COGAT®-M	93	0.00	20.00	10.23	5.04
COGAT®-NB	93	9.00	39.00	21.01	7.94

Note: CHEXI-P: The Childhood Executive Functioning Inventory Parent Form, CHEXI-T: The Childhood Executive Functioning Inventory Teacher Form, WCST: The Wisconsin Card Sorting Test; TA: Trials Administered, TE: Total Errors, TC: Total Correct Responses, CC: Completed Categories, PR: Perseverative Responses, PE: Perseverative Errors, NPE: Non-perseverative Errors, PPE: Percent Perseverative Errors, TC1st:Trials to Complete The First Category, CLR: Conceptual Level Responses, PCLR: Percent Conceptual Level Responses, FMS: Failure to Maintain Set, LL: Learning to Learn, DSF: Digit Span Forwards, DSB: Digit Span Backwards, DST: Total Digit Span Scores, CogAT®-F: The Nonverbal Battery of CogAT®/Figure Classification CogAT®-M: The Nonverbal Battery of CogAT®/Matrices CogAT®-NB: The Nonverbal Battery of CogAT® total score.

Validity and Reliability Analyses

The Factor (Component) Structure of the CHEXI Parent and Teacher

To explore the factor (component) structure of the CHEXI, separate analyses were conducted for parent and teacher forms using Principal Component Analyses (PCA) with orthogonal varimax rotation.

The sampling adequacy of the items was assessed by Kaiser-Meyer-Olkin's Measure of Sampling Adequacy (KMO), and all items were included in the study unlike the original CHEXI study (Thorell & Nyberg, 2008) for all displaying an acceptable sampling adequacy higher than .60 (Brace et al., 2006). KMO's for the CHEXI forms were .85 and .92 for parent and teacher forms, respectively. Additionally, Bartlett's test of sphericity was significant for both parent and teacher forms (p<.01).

Results of these analyses revealed three and six factors with eigenvalues above 1 for teacher and parent forms, respectively. However, regarding scree-plots, item distributions and factor analytic computations of the original CHEXI forms (Thorell & Nyberg, 2008), factor structures of both forms were restricted to two factors as Working Memory (WM, first factor) and Inhibition (I, second factor). The correlations between two factors were found as r =.48 for parent ratings and r =.60 for teacher ratings via computing analyses with oblimin oblique rotation.

The explained total variance of the CHEXI was 39.4 % for the parent form and 59.4 % for the teacher form. The first factor explained 22.9 % of the variance whereas the second factor accounted for 16.4 % of the total variance, for the parent ratings. Regarding teacher ratings, the explained total variance was 35.8 % for the first factor and 23.6 % for the second factor. All items displayed loadings greater than .32 (10 % overlapping variance) (Tabachnick & Fidell, 2007).

Despite having different loadings, results of this study demonstrated the same factor patterns with the original CHEXI regarding teacher forms. The CHEXI parent form also displayed the same factor pattern with the original CHEXI except the eighth item. This item had very similar loadings on the first (WM) and the second (I) factors; .44 and .43, respectively. Due to the content of the item, original factor loadings and teacher loadings of the item in this study, the item was decided to be evaluated under the second factor. Moreover, the twenty-fifth and twenty-sixth items, excluded from the original CHEXI study, were accepted to be under the second and the first factors in this study, respectively, according to the content of the items also supported by factor loadings. Items and factor loadings for both parent and teacher ratings are presented in Table 3.

The Reliability of the CHEXI Parent and Teacher

Internal consistency results of the CHEXI were determined by computing Cronbach alpha coefficients. Data revealed good Cronbach alpha scores as follows; .91 for the CHEXI parent form and .97 for the CHEXI teacher form. Two subscales of the CHEXI also revealed high internal consistency scores as .86 for parent ratings and .95 for teacher ratings regarding the Working Memory Subscale, and .82 for parent ratings and .90 for teacher ratings in terms of the Inhibition Subscale.

Table 3

The Factor (Component) Structure of the CHEXI for Parent and Teacher Forms

	Parents		*Teachers*	
	Working Memory	*Inhibition*	*Working Memory*	*Inhibition*
24. Has difficulty keeping things in mind while he/she is doing something else	**.76**	.00	**.83**	.00
20. Has difficulty with tasks or activities that involve several steps	**.71**	.00	**.81**	.00
1. Has difficulty remembering lengthy instructions	**.67**	.00	**.66**	.36
21. Has difficulty thinking ahead or learning from experience	**.66**	.00	**.70**	.39
23. Has difficulty doing things that require mental effort, such as counting backwards	**.63**	.00	**.75**	.00
26. Has difficulty understanding the concept of time compared to same-aged peers	**.60**	.00	**.63**	.00
17. Has difficulty telling a story about something that has happened so that others may easily understand	**.58**	.00	**.71**	.32
19. Has difficulty understanding verbal instructions unless he/she is also shown how to do something	**.57**	.00	**.80**	.00
3. Has difficulty remembering what he/she is doing, in the middle of an activity	**.55**	.00	**.81**	.00
7. Has difficulty coming up with a different way of solving a problem when he/she gets stuck	**.54**	.32	**.77**	.00
14. Has difficulty carrying out activities that require several steps (e.g. for younger children, getting completely dressed without reminders; for older children, doing all homework independently	**.53**	.35	**.62**	.49
6. When asked to do several things, he/she only remembers the first or last	**.48**	.32	**.77**	.32
8. When something needs to be done, he/she is often distracted by something else	**.44**	**.43**	.56	**.63**

(*continued)*

Table 3 *(continued)*

	Parents		*Teachers*	
	Working Memory	*Inhibition*	*Working Memory*	*Inhibition*
12. Has difficulty planning for an activity (e.g., remembering to bring everything necessary for a field trip or things needed for school	**.43**	.37	**.73**	.00
9. Easily forgets what he/she is asked to fetch	**.39**	.00	**.70**	.00
11. Has clear difficulties doing things he/she find boring	.00	**.71**	.41	**.64**
18. Has difficulty stopping an activity immediately upon being told to do so. For example, he/she needs to jump a couple of extra times or play on the computer a little bit longer after being asked to stop	.00	**.70**	.00	**.70**
13. Has difficulty holding back his/her activity despite being told to do so	.00	**.61**	.00	**.71**
22. Acts in a wilder way compared to other children in a group (e.g., at a birthday party or during a group activity)	.00	**.56**	.00	**.64**
15.In order to be able to concentrate, he/she must find the task appealing	.41	**.56**	.44	**.60**
10. Gets overly excited when something special is going to happen (e.g., going on a field trip, going to a party	.00	**.55**	.00	**.52**
16. Has difficulty refraining from smiling or laughing in situations where it is inappropriate	.35	**.51**	.00	**.73**
25. Thinks out loud, even when performing relatively simple tasks	.41	**.44**	.39	**.53**
4. Has difficulty following through on less appealing tasks unless he/she is promised some type of reward for doing so	.00	**.43**	.43	**.52**
5. Has a tendency to do things without first thinking about what could happen	.37	**.41**	.37	**.66**
2. Seldom seems to be able to motivate him-/herself to do something that he/she doesn't want to do	.00	**.41**	.48	**.62**

Extraction Method: Principal Component Analysis, Rotation Method: Varimax with Kaiser Normalization a. Rotation converged in 3 iterations (N_{parent}=134,$N_{teacher}$=129).

Moreover, split-half reliability analyses were conducted for parent and teacher forms of the CHEXI. The first part of the scale included items from 1 to 13 whereas the second part involved items from 14 to 26.

Regarding the CHEXI Parent form, Cronbach alpha coefficients were .81 for the first part and .87 for the second part. In addition, Guttman split-half reliability coefficient for the CHEXI Parent was .87. In terms of teacher ratings, Cronbach alpha coefficients were computed as .92 both for the first and second parts. Besides, Guttman split-half reliability coefficient for the CHEXI Teacher was found to be .93.

Finally, for the CHEXI Parent, data revealed split-half reliability results as follows: .89 for Working Memory Subscale and .75 for Inhibition Subscale. Guttman split-half reliability coefficients for subscales of the CHEXI Teacher were .94 for Working Memory and .80 for Inhibition.

The Factor (Component) Structure of the Wisconsin Card Sorting Test

To explore the factorial structure of the Wisconsin Card Sorting Test Principal Component Analyses were carried with orthogonal varimax rotation. The redundant WCST scores were excluded from the analyses and computations were conducted with ten scores of the WCST (see Table 4).

Results of these analyses demonstrated three factors with eigenvalues above 1. This extraction was accepted regarding the content of the factors and scree plot illustrations. These factors were named as “perseveration/cognitive flexibility”, “conceptualization/reasoning” and “set maintenance” due to the commonalities of the groups and previous studies (Yeniçeri & Atalay, 2008).The explained total variance of factors was 92.71 %, and all items displayed loadings greater than .32 (10 % overlapping variance) (Tabachnick & Fidell, 2007). Components and loadings for the WCST are presented in Table 4.

Correlational Analyses

Regarding the hypotheses of the study, the associations between the test scores: namely, the CHEXI Parent (CHEXI-P), CHEXI Teacher (CHEXI-T), Working Memory Subscale of the CHEXI Parent (CHEXI-P/WM) and Teacher (CHEXI-T/WM), Inhibition Subscale of the CHEXI Parent (CHEXI-P/I) and Teacher (CHEXI-T/I), the Wisconsin Card Sorting Test (WCST), Digit Span Tasks (DST) and CogAT® Nonverbal Battery scores were investigated. Pearson Product Moment Correlations were computed between the aforementioned scores. All of the results were also presented in a correlation matrix in Table 5.

As illustrated in Table 5, computations regarding the *CHEXI –P* revealed a low but significant relationship with the CHEXI-T (r = .26, p < .01). However, results regarding the CHEXI-P failed to reach any significance for any of the WCST, DST and CogAT® scores.

Results concerning *CHEXI-T* displayed low but significant correlations with the WCST Completed Categories (r = -.19, p < .05), Perseverative Responses, Perseverative Errors, Percent Perseverative Errors (range r = .25 to r = .26, p < .01). Additionally, the CHEXI-T scores revealed low correlations with all of the DST scores (range r = -.28 to -.33, p < .01). There were no significant relationships between the CHEXI-T and CogAT® scores.

Table 4

The Factor (Component) Structure of the WCST

	Perseveration/ Cognitive Flexibility	*Conceptualization/Reasoning*	*Set Maintenance*
Perseverative Responses	**.974**		
Percent Perseverative Errors	**.967**		
Perseverative Errors	**.965**		
Nonperseverative Errors		**.879**	-.345
Trials to Complete the 1st Category		**.785**	
Completed Categories	-.588	**-.764**	
Percent Conceptual Level Response	-.624	**-.691**	.330
Total Error	.637	**.680**	
Conceptual Level Response	-.550	**-.632**	.504
Failure to Maintain Set			**.942**

Extraction Method: Principal Component Analysis, Rotation Method: Varimax with Kaiser Normalization a. Rotation converged in 4 iterations (N=125).

Regarding the *Working Memory Subscale of the CHEXI Parent* form, data did not reveal significant correlations with any of the test scores except Digit Span Backwards (r = -.22, p < .05). On the other hand, the *Working Memory Subscale of the CHEXI Teacher* demonstrated significant correlations with *Perseveration* scores of the WCST (range r = .23 to r = .24, p < .05), all of the Digit Span Scores (range r = -.30 to r = -.37, p < .01) and all of the CogAT® scores (range r = -.24 to r = -.26, p < .05).

Data did not reveal significant correlations between the *Inhibition Subscale of the CHEXI Parent* and remaining test scores. However, there were significant correlations between the *Inhibition Subscale of the CHEXI Teacher* and the WCST Perseveration Scores (r = .27, p < .01) as well as Completed Categories (r = -.22, p < .05). Additionally, Inhibition Subscale of the CHEXI Teacher was significantly associated with all of the Digit Span Scores (range r = -.21, p < .05 to r = -.25, p < .01). There were no significant correlations between Inhibition Subscale of the CHEXI Teacher and CogAT® scores.

Moreover, CogAT® Figure Classification Subtest scores and were significantly correlated with all of the WCST scores (range r =-.43 to r =.42, p < .01) except the WCST-Failure to Maintain Set and Trials to Complete the 1st Category scores. However, CogAT® Matrices Subtest scores displayed significant correlations with only two of the WCST scores such as Total Errors and Non-perseverative Errors (range r =-.33 p < .01 to r =-.26, p < .05). Finally, CogAT® Nonverbal Battery Total scores showed significant correlations with all of the WCST scores except the WCST Failure to Maintain Set and Trials to Complete the 1st Category scores (range r =-.40 to r =.34, p < .01).

Furthermore, all Digit Span scores (forwards, backwards and total) revealed significant correlations with the WCST scores (range r =-.32 to r = .36, p < .01) except the WCST-Trials to Complete the 1st Category and Failure to Maintain Set. Finally, data revealed significant relations between all CogAT® and Digit Span scores (r =.22, p < .05 to r = .41, p < .01) except Digit Span Forwards and CogAT®-Figures as well as CogAT® Total Nonverbal scores (see Table 5).

The Effects of Demographic Variables on Test Scores

The Effects of Demographic Variables on the CHEXI Scores

In order to explore the effects of the demographic variables on the CHEXI Parent and Teacher scores separate between subjects Multivariate Analyses of Variance (MANOVA) were computed. Eleven demographic variables included in these analyses were handedness, grade, the type of school, gender, age total, number of siblings, birth order, preschool education, medication history, maternal and paternal education levels. Eleven separate one way MANOVAs were carried out. All results were checked for homogeneity of variance-covariance matrices in terms of Box's Test of Equality of Covariance Matrices. Additionally, results were examined for equality of variances via Levene's Test of Equality of Error Variances (Brace, Kemp & Snelgar, 2006).

Table 5

The Correlation Matrix for All Measures

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1.CHEXI-P	--	.26**	.89**	.90**	.14	.32**	.03	.02	.15	.13	-.08	.14	-.10	-.01	-.03	-.04	-1.7	-.06	-.12	-.04	-.15	-.11
2.CHEXI-T		---	.23*	.26**	.94**	.91**	.17	-.19*	.25**	.26**	.01	.26**	.09	-.13	-.16	.05	-.20	-.19	-.22	-.28**	-.29**	-.33**
3.CHEXI-P/WM			---	.63**	.14	.24*	.08	-.05	.16	.15	-.03	.15	-.09	-.04	-.07	.01	-.16	-.10	-.14	-.07	-.22*	-.17
4.CHEXI-P/I				---	.13	.37**	.02	.05	.15	.15	-.11	.16	-.08	-.01	-.02	-.07	-.12	.04	-.03	-.00	-.03	-.02
5.CHEXI-T/WM					---	.72**	.15	-.16	.23*	.24*	.01	.24*	.07	-.12	-.15	.03	-.24*	-.23*	-.26*	-30**	-34**	-37**
6.CHEXI-T/I						---	.18	-22*	.27**	.27**	.03	.27**	.12	-.16	-.18	.04	-.17	-.14	-.17	-.23*	-.21*	-.25**
7.WCST-TE							---	-.91**	.77**	.81**	.80**	.78**	.46**	-.91**	-.99**	-.39**	-.43**	-.26*	-.38**	-.25**	-.30**	-.32**
8.WCST-CC								---	.71**	-.73**	-.72**	-.71**	-.59**	.85**	.92**	.20*	.37**	.19	.30**	.26**	.35**	.36**
9. WCST-PR									---	.99**	.23**	.99**	.26**	-.69**	-.76**	-.28**	-.31**	-.12	-.23*	-.22*	-.22*	-.26**
10.WCST-PE										---	.29**	.99**	.27**	-.72**	-.79**	-.30**	-.33**	-.14	-.25*	-.21**	-.22*	-.25**
11.WCST-NE											---	.25**	.47**	-.73**	-.78**	-.31**	-.39**	-.33**	-.40**	-.19*	-.27**	-.27**
12.WCST-PPE												---	.26**	-.73**	-.77**	-.33**	-.31**	-.11	-.22*	-.21*	-.21*	-.24**
13.WCST-TC 1st													---	-.49**	-.50**	-.08	-.04	.05	.01	-.13	-.17	-.17
14.WCST-CLR														---	.94**	.61**	.35**	.10	.23*	.21*	.26**	.27**
15.WCST-PCLR															---	.43**	.42**	.21	.34**	.24**	.31**	.32**
16.WCST-FMS																---	.17	.00	.09	.07	.09	.09
17.COGAT-F																	---	.59**	.86**	.12	.34**	.27*
18.COGAT-M																		---	.92**	.22*	.38**	.35**
19.COGAT-N																			---	.19	.41**	.35**
20.DST-F																				---	.50**	.86**
21.DST-B																					---	.88**
22.DST-T																						---

Note: $*p < .05$, $**p < .01$ (two tailed). Note: CHEXI-P: The Childhood Executive Functioning Inventory Parent Form, CHEXI-T: The Childhood Executive Functioning Inventory Teacher Form, CHEXI-P/WM: Working Memory Subscale of the CHEXI Parent; CHEXI-P/I: Inhibition Subscale of the CHEXI Parent; CHEXI-T/WM: Working Memory Subscale of the CHEXI Teacher; CHEXI-T/I: Inhibition Subscale of the CHEXI Teacher; WCST: The Wisconsin Card Sorting Test; TE: Total Errors, CC: Completed Categories, PR: Perseverative Responses, PE: Perseverative Errors, NE: Non-perseverative Errors, PPE: Percent Perseverative Errors, TC1st:Trials to Complete The First Category, CLR: Conceptual Level Responses, PCLR: Percent Conceptual Level Responses, FMS: Failure to Maintain Set; DSF: Digit Span Forwards, DSB: Digit Span Backwards, DST: Total Digit Span Scores, CogAT®-F: The Nonverbal Battery of CogAT®/Figure Classification CogAT®-M: The Nonverbal Battery of CogAT®/Matrices. CogAT®-N: The Nonverbal Battery of CogAT® Total Score.

As a result, there revealed a significant effect of *age total* on the combined dependent variable the CHEXI scores (F (2,112) = 4.70, p<.05; Wilks' λ =.9; partial η^2= .07). Analyses of each individual dependent variable, using a Bonferroni adjusted alpha level of .025 in order to avoid Type 1 error, demonstrated that there was no contribution of the CHEXI-P (F (1,113) = 1.33, p=.250; partial η^2= .01). The two groups differed in terms of the CHEXI-T (F (1,113) = 5.73, p=.018; partial η^2= .05). MANOVA results can be seen in Table 6.

Table 6

MANOVA Results of the CHEXI Parent and Teacher for Age Total Variable

Dependent Variables (CHEXI P/T scores)	*SS*	*df*	*MS*	*F*	η^2	*p*
CHEXI-P	325.93	1	325.93	1.33	.012	.250
CHEXI-T	1416.97	1	1416.97	5.73	.048	.018
Error						
CHEXI-P	27602.45	113	244.27			
CHEXI-T	27929.55	113	247.16			

Note: p<.025.

Comparison of the mean scores for the CHEXI-T suggested that participants below 84 months ($M_{1^{st}\ age\ total}$= 58.62, SD= 2.16) have higher scores than the ones above ($M_{2^{nd}\ age\ total}$ = 51.58, SD= 1.10). Results are illustrated in Table 7.

Table 7

Means and Standard Deviations for the CHEXI-T by Age Total

	Age Total	*M*	*SD*	*N*
CHEXI-T	age total < 84.00	58.62	2.16	53
	age total ≥ 84.00	51.58	1.10	62

Note: Age total represents participants' ages in terms of months.

Similarly, there was a significant effect of *gender* on the set of dependent variable the CHEXI (F (2,112) = 4.66, p<.05; Wilks' λ =.9; partial η^2= .08). Again, analyses of each individual dependent variable, using a Bonferroni adjusted alpha level of .025, revealed that there was no contribution of the CHEXI-P (F (1,113) = 2.52, p=.115; partial η^2= .02). The two groups differed only in terms of the CHEXI-T (F (1,113) = 8.52, p=.004; partial η^2= .07). Related coefficients are presented in Table 8.

Table 8

MANOVA Results of the CHEXI Parent and Teacher for Gender Variable

Dependent Variables (CHEXI P/T scores)	*SS*	*df*	*MS*	*F*	η^2	*p*
CHEXI-P	609.57	1	609.57	2.52	.022	.115
CHEXI-T	2058.35	1	2058.35	8.52	.070	.004
Error						
CHEXI-P	27318.81	113	241.76			
CHEXI-T	27288.17	113	241.49			

Note: p<.025.

Comparison of the mean scores for the CHEXI-T demonstrated that males (M= 59.92, SD= 2.27) have higher scores than females (M= 51.31, SD= 1.88). Results can be seen in Table 9.

Table 9

Means and Standard Deviations for the CHEXI-T by Gender

	Gender	*M*	*SD*	*N*
CHEXI-T	Male	59.92	2.27	47
	Female	51.31	1.88	68

<u>The Effects of Demographic Variables on the WCST Scores</u>

Regarding the same concerns (see the previous section), separate between subjects Univariate Analyses of Variance (ANOVAs) were performed for the most commonly used WCST scores; namely, completed categories and perseveration scores (Heaton, 1981; Li et al., 2004). The demographic variables included in these analyses were grade, gender and the type of school in addition to the number of siblings and maternal education levels. It was preferred to perform the analyses with each demographic variable separately in order to obtain more precise results. Thus, separate one-way between subjects ANOVAs were carried out for each of the WCST scores. Data did not reveal any significant results for these computations. None of these demographic variables seemed to relate with *the aforementioned* scores of the WCST.

The Effects of Demographic Variables on Digit Span Backwards Scores

To provide information regarding the effects of demographic variables on Digit Span Backwards scores, separate 2 X 2 X 2 and 3 X 3 between subjects Univariate Analyses of Variance (ANOVAs) were carried out. The demographic variables included in the analyses were grade, gender and the type of school (2X2X2) as well as numbers of siblings and maternal education levels (3X3). Overall, *grade* had a significant main effect on Digit Span Backwards (F (1,125) = 17.50, p=.000; partial η^2= .12). Also, there was a significant main effect of *gender* on Digit Span Backwards scores (F (1,125) = 5.14, p=.025; partial η^2= .04). These results are presented in Table 10.

Table 10

2X2X2 Between Subjects ANOVA Results for Digit Span Backwards

	df	*F*	η^2	*p*
Grade	1	17.50	.123	.000
Gender	1	5.14	.040	.025
The type of school	1	1.73	.014	.191

Note: p<.05

The comparison of mean scores for Digit Span Backwards displayed that first grade students (M= 2.40, SD=.21) have lower scores than second graders (M= 3.71, SD=.24). Additionally, mean scores for this assessment revealed that girls (M= 3.41, SD=.21) performed better than the boys (M= 2.70, SD=.23) did. Results are illustrated in Table 11.

Table 11

Means and Standard Deviations for Digit Span Backwards by Gender and Grade

		M	*SD*	*N*
Gender	Male	2.70	.23	61
	Female	3.41	.21	72
Grade	First	2.40	.21	66
	Second	3.71	.24	67

The Effects of Demographic Variables on CogAT® Nonverbal Battery Scores

In order to explore the effects of demographic variables on test scores, separate 2 X 2 X 2 and 3 X 3 between subjects Univariate Analyses of Variance (ANOVAs) were carried out for CogAT® Nonverbal Battery scores. The same demographic variables of the previous sections were included in the analyses. Overall, *grade* was significantly related to CogAT® Nonverbal Battery Scores (F (1, 85) = 26.94, p=.000; partial η^2= .24). Additionally, there was a significant main effect of *the type of school* on CogAT® Nonverbal Battery Scores (F (1, 85) = 10.89, p=.001; partial η^2= .11). However, due to uneven sample sizes of public and private school students in this study, the effects of the type school on CogAT® Nonverbal Battery Scores might be problematic. Results of this analysis are presented in Table 12.

Table 12

2X2X2 Between Subjects ANOVA Results for CogAT® Nonverbal Battery

	df	*F*	η^2	*p*
Grade	1	26.94	.241	.000
Gender	1	.668	.008	.416
The type of school	1	10.89	.114	.001

Note: $p < .05$

Mean scores of 2X2X2 ANOVA indicated that first graders (M= 17.83, SD= 1.07) performed poorer than the second graders (M= 26.37, SD= 1.25). Also, mean scores revealed that public school students (M= 19.38, SD=.84) performed poorer than private school students (M= 24.81, SD= 1.42). Results can be seen in Table 13.

Table 13

Means and Standard Deviations for CogAT® Nonverbal Battery by Grade and The Type of School

		M	*SD*	*N*
Grade	First	17.83	1.07	45
	Second	26.37	1.25	48
The type of school	Public	19.38	.84	65
	Private	24.81	1.42	28

CHAPTER 4

DISCUSSION

Results of this study indicated that the CHEXI seems to be a valid instrument that provides information about the daily-life executive functionality of early school-aged children. Factor analytic computations demonstrated that the CHEXI depends on two factors which account for two subscales as “Working Memory” and “Inhibition” for both parent and teacher evaluations. Moreover, this study contributed to the previous factor analytic studies of the WCST by a three-factor solution referring to “perseveration/ cognitive flexibility”, “conceptualization/ reasoning” and “set maintenance”.

However, results indicated that the WCST poorly correlates with the daily-life executive functioning of children, as measured by the CHEXI. On the other hand, this study also demonstrated that there might be differences between parent and teacher evaluations regarding the child’s daily-life executive functionality.

Additionally, data revealed significant intercorrelations between executive functions and other basic cognitive skills such as working memory and fluid intelligence. Finally, it was demonstrated that some of the demographic variables such as gender and grade show significant main effect on basic cognitive skills; namely, working memory, fluid intelligence and executive functions. The aforementioned results will be discussed in the following sections in the view of the current literature.

The Childhood Executive Functioning Inventory (CHEXI)

The primary aim of this study was to adapt the CHEXI into Turkish, and provide preliminary validity and reliability data. The Turkish version of the CHEXI demonstrated good psychometric properties. The items of the Turkish version loaded on the same factors as presented in the original study, and they were grouped under the same subscales (Thorell & Nyberg, 2008).

Regarding teacher ratings, data clearly revealed two subscales as “Working Memory” and “Inhibition” as it was indicated in the Sweden study. On the other hand, parent ratings also demonstrated the same item distributions except the eighth item (i.e. “When something needs to be done, he/she is often distracted by something else”). Since this item revealed nearly same loadings on both factors, and the content of the item was more relevant to one of the clusters, this item was decided to be remained under the same subscale as it was in the original version. In that sense, it might be stated that parent ratings also indicated similar factor structure with the original version.

However, parent ratings failed to reveal significant correlational data. Thus, most of the interpretations in this chapter depend on teacher ratings while referring to the CHEXI. Despite of being unclear, this might stem from the reason that items might be more familiar to teachers to make more relevant evaluations. This issue will be evaluated in detail in the following sections. Overall, these results indicate the need to conduct more studies to reach better evaluations.

Unlike the original version, all items of the CHEXI were included in the Turkish version since all items revealed sufficient psychometric properties. As it is indicated in the original study, it was also not possible to differentiate other abilities such as regulation and planning from working memory and inhibition abilities at this age group, thus, results demonstrated the best fit in terms of two factor solutions leading to two subscales. Hence, the Turkish version of the CHEXI included 26 items that were grouped into two subscales as “Working Memory” and “Inhibition”. As it can be inferred from the two subscales, the CHEXI aimed to tap two basic executive functions; namely, inhibition and working memory (Bodnar et al., 2007; McNab et al., 2008).

Different from the original version, this study did not include test-retest reliability scores for the CHEXI; however, internal consistency and split-half reliability results demonstrated high scores referring to good reliability.

Another difference from the original study was the age range of the participants. The Swedish version of the CHEXI included children at the ages of 4-7; however, the age range of the child participants of this study centered on the ages of 6-7. This difference stemmed from some practical reasons such as permission policies or reaching school-age sample more conveniently.

Overall, these results indicate encouraging signs that it might be useful to conduct more studies with the CHEXI in order to provide further reliability and validity information. Finally, results demonstrate that the CHEXI seems to be a valid instrument tapping basic executive abilities in a condense and convenient fashion.

The Wisconsin Card Sorting Test (WCST)

One of the statements of this study was to contribute to the previous factor analytic studies of the WCST in addition to deliver normative information. Results indicated very similar normative information for this age group with previous studies in the literature (Roselli & Ardila, 1993; Shu et al., 2000). On the other hand, a three factor model identical to Yeniçeri & Atalay's (2008) study was obtained. Moreover, this factor structure was also similar to Greeve et al.'s (2002) three factor solution referring to "cognitive flexibility", "problem solving" and "response maintenance" factors. The first factor of the current study was identified as "perseveration/cognitive flexibility", the second factor referred to "conceptualization/reasoning", and the third factor was labeled as "set maintenance".

This study was also a contribution to the huge amount of studies in the literature stating that the WCST primarily captures cognitive flexibility or shifting abilities, due to very high loadings on the perseveration factor (Anderson, 2001; Berg, 1948; Crone et al., 2004; Davis & Nolen-Hoeksema, 2000; Vauth, Rüsch, Wirtz & Corrigan, 2004). More specifically, it should be noted that executive functioning is regarded to be an umbrella concept including several cognitive abilities, and it is widely accepted that the WCST is one of the most commonly used assessment tools in executive functioning evaluations (Anderson, 2001). In that sense, it might be appropriate to state that the WCST is responsible to assess executive functions in a global fashion; however, *the most dominant* feature captured by this tool seems to be perseveration or cognitive flexibility abilities. As a footnote, this feature is clearly manifested in the behavioral realm apparent in the correlations between perseveration related scores (e.g. perseverative errors, categories completed) of the WCST and Inhibition Subscale of the CHEXI (i.e. teacher form). Since perseveration refers to the inability to *inhibit* a dominant or previously learned response or the incapability of cognitive flexibility, these results do not seem surprising (Berger, 2009; Bull & Scerif, 2001; Deak & Narasimham, 2003).

Ecological Validity (Behavioral Correlates)

A very high proportion of studies in examining the associations between traditional child neuropsychological assessment tools and behavioral rating instruments demonstrate absent or low correlations between these two kinds of measures (Anderson et al., 2002; Bodnar et al., 2007; Brewis, 2002; Mahone et al., 2002; Mahone & Hoffman, 2007; Mangeot et al., 2002; McCandless & O'Laughlin, 2007; Silver, 2000; Vriezen & Pigott, 2002).

Results of this study also indicated very low correlations between the WCST and the CHEXI scores (i.e. teacher form). Moreover, analyses on the associations between these two measures demonstrated that only perseveration and completed categories scores of the WCST can significantly correlate with the global measure of the CHEXI. Studies suggest that the most commonly used scores of the WCST that assess executive control are perseveration scores in addition to the numbers of completed categories (Heaton, 1981; Li et al., 2004). That is to say, the aforementioned scores might deliver more global information about executive abilities as measured by the WCST, without delving into specifications. Additionally, behavioral measures are known as capturing more global aspects of executive abilities (Thorell & Nyberg, 2008). Taken together, it might be assumed that the associations between cognitive and behavioral measures of executive functioning are available on a global level, without capturing more specific aspects of the phenomenon.

More specifically, results demonstrate that the higher correlations between the WCST and the CHEXI rely on perseveration scores. Thus, due to the age range of the sample, it might be reasonable to suggest that lab-based evaluations can dominantly be evident on behavioral contexts in terms of more previously established abilities such as inhibition (Barkley, 2005), even if they can capture other abilities on a cognitive level (Anderson et al., 2002). That is to say, executive abilities other than inhibition might demand more time to become observed in naturalistic environments which cannot be covered in this study. On the other hand, these results might also be interpreted as a support for the argument that the WCST *dominantly* taps perseveration or cognitive flexibility abilities, in spite of being a multifaceted measure of executive functions (Anderson et al., 2002). Nonetheless, it is still evident that there exist low correlations between lab-based and behavioral assessments of the global concept of *executive functions*.

One of the most widely accepted explanations for poor correlations between traditional neuropsychological assessments and behavioral measures depends on the context difference. Traditional neuropsychological assessments are often conducted in quiet, structured environments isolated from distracters (P. Anderson, 2002; V. Anderson et al., 2002; Bennett et. al., 2005; Denckla, 2002; Liss et al., 2001; Vriezen & Pigott, 2002). For instance, authors suggest that executive dysfunction patients performing appropriately (i.e. providing right answers to interview questions or doing well on cognitive tasks) in clinical settings might fail to maintain similar patterns in the external life (Anderson, 2002; Bennett et al., 2005; Vriezen & Pigott, 2002). Additionally, Gilotty, Kenworthy, Sirian, Black & Wagner (2002) demonstrate that children with autism perform better in lab-based procedures than real-life. Since real life is full of challenge, structured clinical settings are criticized as not being a representative of the actual functioning of an individual in daily-life.

Another factor that lessens the correlations between performance-based assessment procedures and behavioral ratings might be the contribution of the experimenter. There are external sources (i.e. experimenter) in the classical neuropsychological assessment procedures informing the examinee for the initiation and maintenance of the task which constitute executive help in addition to emotional support. Despite of trying to be at least neutral, the experimenter provides a supportive environment for the examinee which eases the execution process (Anderson, 2002; Stuss & Alexander, 2000). However, in real-life, especially in collective activities (e.g. in school or extracurricular courses), one may not always get the opportunity to have additional executive and emotional supervisors, thus, this lack might lead up to discrepant test results.

One of the basic arguments in evaluating discrepant results of behavioral and lab-based instruments depends on the assumption of assessing different aspects (i.e. cognitive and behavioral) of executive functions (Bodnar et al., 2007; Brewis, 2002). Cognitive measures are regarded to assess narrow and specific cognitive skills whereas behavioral measures are defined to capture broader aspects of executive functions which might either be an advantage or disadvantage (Bodnar et al., 2007; Gioia & Isquith, 2004; Isquith, Gioia & Epsy, 2004; Mangeot et al., 2002; Thorell & Nyberg, 2008). Ironically, executive function tests might, by nature, lack to tap specific skills due to their multifaceted characteristic compared to other neuropsychological concepts (Anderson, 2002; Bennett et al., 2005). Nevertheless, some authors argue that these aspects might be related to different brain regions; cognitive assessments were considered to depend on dorsolateral prefrontal cortex and behavioral measures were suggested to activate orbitofrontal functions which cannot be captured within the scope of this research (Anderson et al., 2002).Overall, lower correlations between these two assessment types might stem from different natures and functions of the testing instruments.

The following explanation regarding lower correlations between lab-based and behavioral procedures might be related to the studied sample that affects testing instruments. Neuropsychology literature include a huge amount of neuropsychological tests (e.g. the WCST, Tower of Hanoi Test) developed for adults and then adapted to children. Most authors in the child neuropsychology literature propose that adult-oriented tests might possess limitations of generalization when applied to children sample due to different brain developments and capacities (P. Anderson, 2002; V. Anderson et al., 2002; Vriezen & Pigott, 2002). These tests are suggested to be more sensitive in detecting especially adult cognitive deficits. Hence, it should be better to use instruments in child studies specifically developed for children. Since the child version of the WCST used in this study is identical with the original adult instrument, it might be informing to evaluate discrepant results cautiously.

As mentioned in the first section, executive functioning is an umbrella term including several sub-skills. The multifaceted characteristic of executive skills inevitably brings out of questions about measurement issues. Studies address the need for using neuropsychological batteries capturing several instruments to assess executive skills in order to reach comprehensive results (Anderson, 2001; Bennett et al., 2005;

Chaytor & Schmitter-Edgecombe, 2003). With this notion in mind, it might be inadequate to claim that executive functions display poor ecological validity by depending on single measurement tools for both lab-based and behavioral assessments. By this account, this study claims that the WCST show low associations with the daily-life executive functioning measure, the CHEXI.

As a second thought, it might be right to consider the developmental course of executive functions, especially while working with children. As mentioned in the first section, neuropsychology literature indicates that the time between seventh and ninth years of life are considered to be one of the critical periods in executive functioning development (Anderson, 2001; Anderson et al., 2002; Hudspeth & Pribram, 1990). In other words, results of the neuropsychological testing conducted with participants within this age range might be colored with the effect of this developmental transition. Alternatively, in their two years of longitudinal study with first and second grade students, Riggs et al. (2003) propose that children of these ages might acquire executive capacities on a cognitive level; however, it might take at least two years to accurately integrate these skills in daily life. Since the mean age of the participants in this study is six years and eleven months, it might be reasonable to evaluate the results with caution before driving final conclusions.

Overall, studies indicate that a holistic way of look might be suitable in the assessment of neuropsychological functions (Anderson et al., 2002; Bodnar et al., 2007; Chaytor & Schmitter-Edgecombe, 2003; Parker & Crawford, 1992). Regarding the different natures of testing tools, more in depth evaluations might be obtained via using both cognitive and behavioral assessment procedures as a neuropsychological battery to reach healthier deductions.

Informant Ratings

Informant ratings are regarded to be the most frequently used way of supportive assessment. However, studies often indicate that the most basic sources in the evaluation of children behavior do not always agree on the child's current functioning (Achenbach et al., 1987; De Los Reyes & Kazdin, 2005; DuPaul & Barkley, 1992; McGee et al., 2000; Schonfeld et al., 2006). Results of this study also demonstrated that there are poor correlations between parent and teacher ratings of the CHEXI. Additionally, data also revealed that parent ratings were of no significance in correlational analyses.

The literature consists of some widely accepted arguments that could explain discrepant evaluations of parents and teachers. Primarily, the different settings such as school or home might give different information to raters due to their different natures (Achenbach et al., 1987; McCandless & O'Laughlin, 2007; Muir-Broaddus et al., 2002). For most of the time, school and home environments possess different stimuli and demand different responses. As mentioned, academic environment requires proper executive abilities from being able to sit on a desk without being fidgety to concentrating on the tasks to complete assignments in order to attain goals. For the most of the time, the school setting asks children to regulate the execution of tasks as well as themselves individually due to child-teacher ratio. Besides, for younger children, home environment often necessitates less compelling planning and sequencing abilities such as preparing required equipments for the school or dressing on their own without reminders. Additionally, home environment contains auxiliary executive agents (e.g. mothers, child minders) enabling more one-to-one executive function support (Anderson, 2002).

More specifically, the literature consists of a huge amount of studies emphasizing teacher ratings in executive functioning challenges which are mostly apparent in academic settings (Mares et al., 2007). For instance, in the 2005 study, Oosterlaan, Scheres & Sergeant demonstrated that predictions about executive functioning could only be available in terms of teacher ratings (not parents), which was exactly the case for the current study. Moreover, Brewis (2002) claims that there are higher correlations between teacher ratings of executive functions and lab-based assessments than parental reports. Furthermore, Loeber, Green & Lahey (1990) state that teachers provide more information about executive function based problems such as hyperactivity or inattentiveness.

Additionally, a body of literature suggests that parental evaluations could be biased due to some parental psychopathology or personality traits (Chi & Hinshaw, 2002; De Los Reyes & Kazdin, 2005; Richters, 1992). For instance, studies indicate that parental stress is one of the chief factors that affect rating biases (Benzies, Harrison & Magill-Evans, 2004; De Los Reyes & Kazdin , 2005; Joyner et al., 2009; Truetler & Epkins, 2003). This issue could be more active in situations such as executive dysfunctions in which parents take the role of being auxiliary executive functions for the most of the time, especially for younger children. In addition, research indicate that ineffective family functioning might also lead to executive functioning problems in children, which refers to two-way interactions (Mangeot et al., 2002). Moreover, there are also studies focusing on the relationship between parent and the child assuming that conflictual relationships might lead to biased ratings (Truetler & Epkins, 2003). This study was not able to test all of these hypotheses; however, these arguments might be reasonable to an extent that parents might experience difficulties to neutralize the confounding effect of emotional loads while evaluating their own children. In other words, teachers might stand more distanced and professional in order to conduct more objective evaluations regarding children's executive behaviors.

On the other hand, the discrepancy between parent and teacher ratings do not necessarily determine that teacher ratings give more reliable information about the child's real functioning (Joyner et al., 2009; Mares et al., 2007). Instead, we can interpret this situation as teachers could have the opportunity to provide more relevant information about executive functioning challenges since they have knowledge to evaluate age-appropriate requirements. Moreover, school environment provides more clues about executive functioning impairments which enable earlier notifications, particularly in terms of inhibition difficulties which are regarded as the chief symptoms of executive dysfunctions (Barkley, 2005; Mares et al., 2007). Additionally, McCandless & O'Laughlin (2007) suggest that parents could provide more information about behavioral problems whereas teachers might detect cognitive difficulties more precisely.

Overall, the discrepancies between parent and teacher assessments shed more light on the importance of regarding informant ratings as mutually inclusive in order to drive more valid and reliable conclusions (Achenbach, 2006; De Los Reyes & Kazdin, 2005; Joyner et al., 2009; McCandless & O'Laughlin, 2007; Slick et al., 2006).

Executive Functions and Working Memory

In this study, the correlations between executive functioning and working memory abilities were investigated in twofold. Since the study accepted the WCST as the primary measure responsible for the assessment of executive functions, the associations between cognitive and behavioral measures of working memory and the WCST were evaluated. Digit Span Backwards, referring to the cognitive assessment tool of working memory, significantly correlated with almost all of the WCST scores. However, the CHEXI Teacher Working Memory Subscale, accounting for the behavioral measure of the working memory concept, revealed significant correlations only for the WCST Perseveration scores. That is to say, results revealed that cognitive assessment tool of working memory in this study captures executive abilities in a full range; however, behavioral assessment of the same concept corresponds to inhibitory abilities, not the whole executive functioning phenomenon. This difference between cognitive and behavioral assessment procedures regarding executive abilities delivers important information.

As mentioned earlier, in their longitudinal study conducted with first and second graders, Riggs et al. (2003) suggest that children at this age range acquire executive capacities on a cognitive level; however, it might last a couple of years to accurately integrate these skills in daily life. Moreover, Gathercole & Baddeley (1993) state that working memory capacities of children around six years of age only enable quantitative results, which complicates qualitative observations. Taken together, results might indicate that working memory, accordingly its relation with executive functions, could be detected more easily on cognitive measures than behavioral observations at this age group. Significant correlations regarding the WCST and Digit Span Backwards task more clearly demonstrate that working memory ability is acquired in this age group, and it is widely correlated with executive functioning abilities; however, this condition is not fully manifested in behavioral contexts. This suggestion is also consistent with Gathercole and her colleagues' (2004) study demonstrating that working memory concept is present at the age of six, with a growing fashion during the following years. In addition, studies in the literature suggest that cognitive measures could capture mental abilities which are not readily evident in behavioral ways (Anderson et al., 2002).

Alternatively, it might be speculated that working memory ability of this age group could only be observed through inhibition abilities. As far as we are concerned, working memory ability necessitates inhibition ability to some extent (McNab et al., 2008; Roberts, Hager & Heron, 1994). For instance, Pennington et al. (1996) suggest that inhibition is a basic component of the working memory system. On the other hand, inhibition is regarded as one of the first executive abilities to develop, which pioneers working memory abilities (Barkley, 2005). Taken together, it might be reasonable to assume that it is less compelling to observe inhibitory aspects of cognitive abilities at this age group due to their earlier development, which allows time for maturation and integration to daily-life. Since cognitive abilities such as working memory have relatively later development, they can only be manifested in behavioral contexts in terms of their inhibition component. In other words, inhibition might have a role in the relations between executive functioning and working memory. In that sense, behavioral assessment of working memory could only relate with inhibitory aspects of executive abilities at this age range. The full manifestation of working memory construct as well as its relations to executive abilities in behavioral environments might necessitate more time to be observed at this age group which demands longitudinal studies.

Moreover, a further look at the associations between cognitive and behavioral working memory measures and the WCST reveal interesting results. The correlations between the global measure of the WCST yield lower significant correlations with Digit Span Backwards in terms of perseveration scores when compared to remaining ones (also see Lehto, 1996). However, the behavioral measure of working memory construct only reaches significant results with regard to perseveration scores. These findings might also be interpreted in the light of the aforementioned arguments to an extent.

These results might support the idea that working memory and inhibition concepts are not isomorphic (Gathercole et al., 2008). Lower correlations between the cognitive measure of working memory and perseveration scores of the WCST demonstrate that working memory concept captures abilities other than perseveration (i.e. inhibition), which leads us to consider that these two constructs necessitate related but distinct abilities. However, this phenomenon cannot be observed as clear as it is at the cognitive level, while making evaluations in behavioral settings. As mentioned earlier, the full range of working memory abilities may not be readily observable at the behavioral level due to the age range of the sample. Thus, behavioral working memory assessments might relate with lab-based executive function instruments only in terms of their inhibition component due to their earlier establishment which makes them more easily detectable in daily-life.

Executive Functions and Fluid Intelligence

Fluid intelligence necessitates problem solving and reasoning abilities in novel situations whereas executive functioning demands management of distracters, reasoning, regulation of attention, memory and other cognitive processes in the face of unfamiliar stimuli (Anderson, 2001; Gray et al., 2003). Accordingly, it would not be unreasonable to expect significant correlations between these two constructs due to their commonalities which are also supported by the literature (Unsworth et al., 2009; Zook et al., 2004). Results of this study also revealed significant associations between executive abilities and fluid intelligence constructs. It might be assumed that since both concepts ask for the use of reasoning and regulation abilities in novel conditions, these two abilities might be the underpinnings of fluid intelligence and executive functions relations; however, it would be better to conduct more research on this issue via more specific assessment procedures.

Working Memory and Fluid Intelligence

One of the hypotheses of this study asked that these two constructs could be related due to several commonalities. Since both demand the activation of reasoning, adaptation and abstraction capacities, results indicated significant relationships between working memory assessments and fluid intelligence. This finding is highly consistent with the literature (Ackerman et al., 2005; Blair, 2006; Colom et al., 2005; Colom et al., 2006; Colom et al., 2008; Conway et al., 2003; Engle et al., 1999, Kane et al., 2005; Martinez

& Colom, 2009; Shelton et al., 2009; Süβ et al., 2002; Unsworth, 2010). In other words, both the CHEXI Working Memory Subscale scores and Digit Span Backwards task scores displayed significant associations with CogAT® Nonverbal Battery scores. At the first glance, these results also suggest that the differences in the assessment procedures (i.e. cognitive and behavioral measures) of working memory concept do not produce a discrepancy on the working memory and *gf* relationship. However, when we take a deeper look, we could see that the correlation between CogAT® Nonverbal Battery scores and the behavioral working memory measure is r=.26 (p<.05) whereas the correlation between CogAT® Nonverbal Battery scores and the cognitive working memory tool is r=.41(p<.01). That is to say, results regarding different assessment procedures require cautious explanations.

As mentioned in the first chapter, studies in the literature regarding the relations between working memory and fluid intelligence cover discrepant arguments. A body of authors suggests that working memory and fluid intelligence abilities refer to the same construct due to very high correlations between the measures of these concepts (Blair, 2006). On the other side, some authors oppose to these arguments defending the fractionation of working memory and fluid intelligence as well as executive functions (Ackerman et al., 2005; Burgess et al., 2006; Conway et al., 2003; Engle et al., 1999; Garlick & Sejnowski, 2006; Heitz et al., 2006; Kane et al., 2005). Since the results of this study indicate maximum moderate correlations between working memory and fluid intelligence measures, it might be reasonable to state that these two concepts share common properties rather than being identical constructs. As a footnote, the relatively lower levels of correlations between working memory and fluid intelligence measures in this study might be a matter of testing instruments which might be revised in the following studies. For example, Digit Span Backwards task is regarded to demand controlled attention more than short-term memory tasks; however, it is still questioned whether it is a good task or not (Engle et al., 1999). In addition, it might be important to keep in mind that the studies in the literature regarding working memory and fluid intelligence correlations are mostly conducted among adult samples, which might present quite differences in child studies.

The underlying constructs that explain positive correlations between working memory and general fluid intelligence abilities remain controversial. As mentioned earlier, arguments regarding this issue more often focus on two concepts; short-term memory and executive attention (Colom et al., 2005, 2006, 2008; Conway et al., 2003; Engle et al., 1999; Kane et al., 2005; Miyake et al., 2001). As briefly mentioned in the results section, computations regarding Digit Span Forwards did *not* display significant correlations with CogAT® Nonverbal Battery scores. This finding is consistent with a body of studies (Conway et al., 2002; Engle et al., 1999; Kane et al, 2004). Thus, as we accept Digit Span Forwards as a short-term memory task, it might be reasonable to suggest that *at least* short-term memory capacity is *not* the underlying construct predicting the scores of intelligence, particularly fluid intelligence, which leads us to consider the role of executive attention abilities.

However, it would be right to keep in mind that single measure testing would not be sufficient to reach final conclusions. Since it is difficult to differentiate the executive or controlled *attention* part of the executive functioning instrument of this study, arguments defending the responsibility of the executive attention concept in working memory and *gf* relationship remain unclear. Thus, the underlying construct explaining the bond between fluid intelligence and working memory necessitates more scientific research with more specific assessment tools to reach clearer results.

Demographic Characteristics

Gender

As mentioned in the previous sections, this study investigated executive functions in twofold: cognitive and behavioral evaluations. The cognitive instrument, the WCST, did not reveal any gender differences, which was consistent with the literature (Arffa, Lovell, Podell & Goldberg, 1998; Paolo, Tröster, Axelrod & Koller, 1995; Roselli & Ardila, 1993). On the other hand, there were significant gender differences in terms of the CHEXI. Boys were evaluated as being more challenged regarding everyday executive abilities. Since the CHEXI is a very recent instrument, there is no information in terms of gender differences in the CHEXI. However, the literature includes studies demonstrating male disadvantage in other behavioral rating instruments (e.g. BRIEF) (Isquith, Gioia & Epsy, 2004). Overall, these results might depend on the widely accepted argument that boys at this age group show more difficulty primarily in behavioral inhibition, which would affect other executive functions as well.

Results also demonstrated an effect of gender on working memory abilities. Tasks such as digit or word spans are regarded to capture verbal domains, more specifically verbal working memory (Conklin, Curtis, Katsanis & Iacono, 2000; Hansen & Bowey, 1994; Kane et al., 2004). In addition, studies in the literature suggest a female advantage in verbal abilities (Anderson, 2002). Since Digit Span Backwards test of the

WISC-R was applied as the cognitive assessment of working memory abilities, the better scores of female participants seem to be reasonable and consistent with the literature (Lynn & Irwing, 2008). Additionally, despite of not being reported in the results section, this pattern does not change in the behavioral assessment of working memory concept represented by the CHEXI Working Memory Subscales of parents and teachers, which is also consistent with the behavior ratings literature (Isquith et al., 2004).

Grade (Age)

This study revealed significant grade differences in terms of working memory and fluid intelligence abilities. Additionally, there was a significant age effect on executive functioning abilities as measured by the behavioral tool, which was supported by the literature (Isquith et al.,2004). It should be rementioned that in this study grade differences also correspond to age differences since these two concepts were used interchangeably due to high correlations with each other. In that sense, it could also be expressed that age was a significant predictor of working memory and fluid intelligence abilities, which was also supported by the literature (Simcock & Hayne 2003).

For instance, Gathercole et al. (2004) suggest that young children's working memory abilities start to make more sense at the age of six, and this ability matures with age. Similarly, Fry and Hale (2000) state that intelligence rapidly improves during childhood which refers to more advanced reasoning abilities with age. Thus, it might be right to suggest that as children gain cognitive maturation, working memory and fluid intelligence capacities are empowered.

As a footnote, an issue about testing instruments might be taken into account. In this study, the WCST was utilized as an executive functioning measure. On the other hand, Digit Span Backwards and CogAT® Nonverbal Battery were applied as working memory and fluid intelligence measures. The latter instruments are specifically developed for children; however, the WCST is exactly the same as the adult-version. Since these three abilities are accepted to be related with each other, it would not be unreasonable to expect age differences on the WCST. In that sense, with this basic technical difference in mind, future studies might include executive functioning instruments which are specifically developed for children to check for the differentiations on age effects.

Conclusions

This study presents the Turkish version of a new and convenient behavioral rating instrument that specifically evaluates executive functionality of early school-aged children. Results indicate that the CHEXI seems to be a valid instrument that could be used in different settings to provide a global knowledge regarding the executive functionality of children. Moreover, this study also contributes to the previous literature suggesting that the WCST is an extensive measure in executive functioning assessment with dominance on perseveration or cognitive flexibility abilities.

Furthermore, it is also demonstrated that cognitive measures of executive functioning might poorly relate with the daily-life executive functioning, as it is widely argued in the literature. This study addresses the debate on the generalizability of results obtained in clinical settings to naturalistic environments. In that sense, the present study emphasizes the importance of using both cognitive and behavioral assessment procedures in order to obtain an enriched picture regarding the real functionality of the individual.

Moreover, this study also provides a global sense about the developmental status of early school-aged children in terms of basic cognitive abilities such as working memory and fluid intelligence. Overall, the present study primarily reveals the preliminary data in the adaptation of a convenient assessment tool that could be used as a screening instrument for early identifications of executive difficulties leading to intervention and prevention strategies.

Limitations and Future Recommendations

One of the limitations of this study refers to the obligatory pre-selection procedure of teacher ratings. This pre-selection procedure directly affected other testing procedures. Since teachers would be overburdened in the case of evaluating all children in their classes, the amount of children was kept within four to six children for each class. Therefore, these selected participants were rated by their parents and they were included in the cognitive evaluations. To overcome this limitation, teachers were informed to make a distribution among the selected children capturing different academical levels. However, this seems to be quite ineffective because academic performance ratings indicate that 81.3 % of the participants performed *above* the average. Although analyses state that academic performance of the participants were slightly correlated with the testing instruments, results might be colored with this effect to an extent. In that sense, future studies might be redesigned regarding this obligatory selection procedure.

Second, future studies might address some assessment issues. For instance, this study did not include a neuropsychological battery which covers tools tapping lower level abilities such as memory or attention. Since executive functioning is an extensive phenomenon, it might be better to isolate and control the effects of each cognitive skill to provide more precise information. Additionally, it might be better to assess visuo-spatial working memory construct as well as crystallized intelligence to obtain extended information. Moreover, since the WCST is an adult-oriented test, it might be informative to apply an executive functioning instrument which is specifically developed for children. Finally, it would be useful to include an additional behavioral measure aiming at assessing similar functions as the CHEXI (e.g. BRIEF, CEFS) to obtain comparisons to provide more information about validity issues.

Third, it would be better to conduct future studies with a larger sample in order to obtain more valid and reliable results, especially for the CHEXI. Since the sample size of this study remains poor for factor analytic results (Tabachnick & Fidell, 2007), future studies might include larger sample sizes in order to reach healthier evaluations.

Fourth, the distribution of public and private school students were uneven in this study due to procedural obstacles. This unequal sample size might lead to insufficient power that limits to reliably address the effect of this phenomenon. Thus, future studies should balance this distribution.

Fifth, since data revealed discrepant results regarding parent and teacher ratings, future studies might include more comprehensive evaluations to control this issue. For instance, adult participants might fill out additional tests such as stress indexes to determine the confounding effect of emotional packages. Alternatively, parental scores might be divided into two clusters including both fathers and mothers (or at least two adults responsible for the child) in order to shed light on context effects.

Sixth, future studies might include clinical samples which would provide more information about executive dysfunctionality, and would enable comparisons between these two conditions.

Finally, it might be interesting to include neuroimaging techniques in future studies to gain more information about their relations with assessment procedures, especially behavioral ones.

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APPENDIX A

DEMOGRAFİK BİLGİ FORMU

KATILIMCI
NO:_(geçiniz)_________________________
____

VELİNİN YAKINLIK DERECESİ (anne, baba, vs.)___________________________

Çocuğunuzun gün/ay/yıl olarak doğum tarihini yazınız: …/…/…

Çocuğunuzun cinsiyeti:

Annenin mesleğini yazınız:______________________________

Anne halen çalışıyor mu?……………..
Yanıtınız evetse ne kadar zamandır?.........

Annenin eğitim seviyesini işaretleyiniz:

a) Yüksek öğrenim (yüksek lisans ve üstü)

b) Üniversite mezunu

c) Lise mezunu

d)Ortaokul mezunu

e) İlkokul mezunu

f) Okur –yazar

g)Okuma-yazma bilmiyor

Babanın mesleğini yazınız:_______________________________

Baba halen çalışıyor mu?..................
Yanıtınız evetse ne kadar zamandır?..........

Babanın eğitim düzeyini işaretleyiniz:

a) Yüksek öğrenim (yüksek lisans ve üstü)

b) Üniversite mezunu

c) Lise mezunu

d)Ortaokul mezunu

e) İlkokul mezunu

f) Okur -yazar

g) Okuma-yazma bilmiyor

Ailedeki çocuk sayısı kaçtır?_____________
Çocuğunuz kaçıncı çocuk? ……….

Çocuğunuz okul öncesi eğitim (anaokulu,kreş vb.) aldı mı?..........

Çocuğunuzun belirtmek istediğiniz bir sağlık sorunu var mı?

Çocuğunuz düzenli olarak kullandığı bir ilaç var mı? …………

Varsa ilacı belirtiniz………………..

APPENDIX B

BİLGİLENDİRİLMİŞ OLUR FORMU (ebeveyn örneği)

Sayın Veli**,**

Boğaziçi Üniversitesi Psikoloji Bölümü Klinik Psikoloji Yüksek Lisans 2. sınıf öğrencisi Ezgi Kayhan tarafından hazırlanmakta olan"Çocukluk Dönemi Yönetici İşlevler Envanteri için bir Geçerlilik Çalışması: Yönetici İşlevlerin Davranışsal Eşlenikleri " isimli tez araştırmasına birinci ve ikinci sınıf ilköğretim öğrencilerinin velilerinin katılımı beklenmektedir. Bu bağlamda, sizden çocuğunuzun yönetici işlevlerine ilişkin değerlendirmelerinizi içeren " *Çocukluk Dönemi Yönetici İşlev Envanteri'ni* doldurmanız istenmektedir.

Testin tamamlanması yaklaşık 5-10 dakika sürmektedir. Testi bireysel olarak doldurmanız rica edilmektedir. Bu araştırma projesi Boğaziçi Üniversitesi Psikoloji Bölümü öğretim elemanlarının denetimi altında yürütülmektedir.

Çalışmaya katılacak tüm velilerin kimlik bilgileri gizli tutulacaktır. Araştırma gönüllülük esasına dayanmaktadır. Her katılımcı istediği an testi bırakma özgürlüğüne sahiptir.

Sorularınız için aşağıda belirtilen numaraları arayabilirsiniz.

Saygılarımla.

Proje Yürütücüsü	Proje Danışmanı
Ezgi Kayhan	Dr. Nur Yeniçeri
Psikoloji Bölümü	Psikoloji Bölümü Öğretim Görevlisi
Klinik Psikoloji Yüksek Lisans öğrencisi	Boğaziçi Üniversitesi
Boğaziçi Üniversitesi	Tel:---
Tel:---	

Yukarıda anlatılanları okudum ve anladım. Bilgilendirilmiş Olur Formu'nun bir örneğini aldım.

Velinin Adı Soyadı:

İmza:

Tarih: