A STUDY FOR THE WISCONSIN CARD SORTING TEST WITH 6- TO 7-YEAR-OLD TURKISH CHILDREN

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Thesis Abstract

Nihal Yeniad, “A Study for the Wisconsin Card Sorting Test (WCST) with 6- to 7-Year-Old Turkish Children”

The present study focused on exploring the relationships of the WCST with certain working memory (WM) and fluid intelligence (FI) tasks. Specifically, the study aimed a) to examine the relationship between executive functioning (EF) and WM, b) to explore the relationship between WM and FI, c) to probe the relationship between verbal and nonverbal WM capacities, d) to investigate the effects of certain family (mothers’ education and number of siblings) and child (age and gender) characteristics on EF performance.

Eighty-nine 6- to 7-year-old Turkish children participated in the study. The WCST was applied to assess EF. Verbal and visuospatial WM capacities were measured by Digit Span Backward (DSB) and Finger Windows (FW), respectively. The nonverbal battery of Cognitive Abilities Test (CogAT®-NB) was used to evaluate FI.

Certain scores of the WCST were found to be significantly correlated with verbal and visuospatial WM scores indicating that WM is required for some executive functions operated by the WCST. Further, WM tasks showed moderate correlations with the CogAT®-NB score, which appears to be consistent with the argument that WM and FI are related but distinct constructs. Finally, mothers’ education was a significant predictor for children’s EF, WM and FI performances.

Keywords: executive functions, working memory, fluid intelligence, Wisconsin Card Sorting Test, CogAT®

Tez Özeti

Nihal Yeniad, “6–7 Yaş Türk Çocuklarla Wisconsin Kart Eşleme Testi (WKET) Üzerine Bir Çalışma”

Bu çalışmada, WKET’in bazı çalışan bellek (ÇB) ve akışkan zeka (AZ) testleriyle gösterdiği korelasyonlar incelenmektedir. Spesifik olarak, çalışma a) yönetici fonksiyonlar (YF) ve ÇB arasındaki ilişkiyi, b) ÇB ile AZ arasındaki ilişkiyi, c) sözel ve görsel-mekansal ÇB kapasiteleri arasındaki ilişkiyi, ve d) bazı ailesel (annenin eğitimi ve kardeş sayısı) ve çocuğa özgü (cinsiyet ve yaş) özelliklerin YF performansı üzerindeki etkisini araştırmayı amaçlamıştır.

6-7 yaşlarında 89 çocuk çalışmaya katılmıştır. YF’ı ölçmek için WKET kullanılmıştır. Sözel ve görsel-mekansal ÇB kapasiteleri, sırasıyla Ters Sayı Dizisi (TSD) ve WRAML bataryasının bir alt testi olan Finger Windows (FW) ile ölçülmüştür. AZ’nın ölçümü için ise Bilişsel Yetenekler Testi’nin (CogAT®) sözel olmayan bataryası (CogAT®-SOB) uygulanmıştır.

WKET’in sözel ve görsel-mekansal ÇB testleriyle (TSD ve FW) olan korelasyonları, WKET’in gerektirdiği bazı yönetici fonksiyonlar için ÇB’in gerekliliğine işaret etmektedir. Ayrıca ÇB testleri (TSD ve FW) ile CogAT®-SOB arasındaki orta dereceli korelasyonlar, ÇB ve AZ kavramlarının bağlantılı fakat ayrı olduğu iddialarına paralellik göstermektedir. Son olarak, ailesel faktörlerden anne eğitim seviyesinin çocukların YF, ÇB ve AZ performansları için önemli bir yordayıcı olduğu bulunmuştur.

Anahtar sözcükler: yönetici fonksiyonlar, çalışan bellek, akışkan zeka, Wisconsin Kart Eşleme Testi, CogAT®.

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CHAPTER I: INTRODUCTION

Executive Functions: Definition and Theoretical Models

Executive function (EF) is a complex cognitive construct that has been extensively discussed in the literature. Many studies have been conducted to explore different aspects of executive functions in different populations. Over 2500 articles have been published regarding this issue over the last decade (Alvarez & Emory, 2006). Welsh and Pennington (1988; cited in Eslinger, 1996) briefly defined executive function as “the ability to maintain an appropriate problem-solving set for attainment of a future goal” (p. 371).

The term EF covers a number of processes such as planning, strategy generation, inhibitory control, attentional flexibility and working memory. However, there still seems to be no clear consensus on what executive functions are. Eslinger (1996) mentioned that ten researchers in the working group on executive functions at the conference sponsored by the National Institute of Child Health and Human Development in 1994 filled out an informal survey about “what behaviors are indicated by the term of executive functions” (p.380). Although the group members generated thirty-three different terms, only six of them reached a 40 percent or greater agreement rate: 1) self-regulation, 2) sequencing of behaviors, 3) flexibility, 4) response inhibition, 5) planning, and 6) organization of behavior. Therefore, it appears that there has been an ongoing controversy about the possible components of the EF construct.

Research on executive functions has its roots in observations of patients with prefrontal (PFC) damage. It was noticed that patients with PFC lesions show similar difficulties in certain areas such as planning, self control, attentional shift, cognitive flexibility, organization, problem solving, decision-making and abstract thinking (Wise, Murray & Gerfen, 1996; cited in Zelazo & Müller, 2004). Thus, executive deficits began to be explored with such patients (Stuss & Alexander, 2000). However, some studies provided evidence that some frontal patients' performances might remain within the normal limits on EF tests (Ahola et al., 1996; cited in Alvarez & Emory, 2006) while people with non-frontal lesions might perform as poorly as people with frontal lesions (Axelrod et al., 1996; cited in Alvarez & Emory, 2006). Such findings led researchers to study the EF construct in different populations.

A glance at the literature reflects diverse models of EF by various perspectives. Lezak (1995; cited in Jurado & Rosselli, 2007) for instance viewed EFs as the mechanisms that make us "independent, productive and effectively self-serving" since they provide us the ability of planning (p. 213). She postulated four fundamental components of executive functions as *volition, planning, purposive action,* and *effective performance*. In this framework, an executive behavior begins with determining one's needs and initiating an activity for meeting these needs (volition). Then, one has to organize the necessary steps to achieve his or her goal (planning). While doing that, s/he should also think about the possibilities and alternatives. Afterwards, s/he translates the plan in mind into action (purposive action) that requires "the ability by starting, maintaining, stopping, and switching behaviors in an organized and integrated fashion" (p. 622). The last step is to evaluate the effectiveness of one's own performance through self-monitoring. Lezak emphasized that purposive action is particularly necessary for performing novel tasks in contrast to routine or 'over learned' activities. Tucker and Derryberry (1992) also stated that problems in planning and self-monitoring abilities are most salient in unstructured situations as opposed to structured contexts in which instructions provide a clear framework for what to do.

In line with Lezak's emphasis, Borkowski and Burke (1996; cited in Eslinger, 1996) stated that executive functions depend on the steps of "sizing-up the problem" (p. 370) and its probable consequences (*task analysis*), selecting possible strategies to use in solving the problem (*strategy control*), and evaluating the effectiveness of the selected strategy, and if necessary, shifting to another (*strategy monitoring and revision*). This sequential process provides "an orderly rather than a chaotic approach to problems" (p.369).

Zelazo, Carter, Reznick, and Frye (1997) suggested a problem-solving framework for executive functions in which they propose "the temporally distinct phases of executive function" that involves *problem presentation, planning, execution* and *finally evaluation* (p. 200). The function of this sequential process is problem solving, and these phases with certain roles work interactively to solve the problem. According to this point of view, one must have a representation of the problem and its consequences in mind at first. Problem presentation requires the ability of "flexible restructuring of the problem" (Zelazo & Müller, 2004, p. 457). Jacques and Zelazo (2001; cited in Zelazo & Müller, 2004) measured this capacity by using the Flexible Item Selection Task; in which children are shown three cards (e.g., a purple fish, a pink fish, and a pink telephone) and asked to choose two cards that match with each other on one dimension such as shape (e.g., the purple *fish* and the pink *fish*) and then to select two cards that match with each other on another dimension like color (e.g., the pink fish, and the pink telephone). The ability to reconstruct the test item on another dimension requires mental flexibility. Within the proposed model, after the problem is mentally represented, one chooses a plan and starts to execute it. Two capacities are required during the execution process; a) keeping the plan in mind (intending), and b) translating the plan in mind into action (rule use). If one executes a plan, the final phase of problem solving begins: evaluation. In this phase, one evaluates his or her own performance to determine whether it was enough to solve the problem. The evaluation phase involves error detection, and if necessary, error correction by looking over previous steps. According to Zelazo et al. (1997), inflexibility might also occur at each phase of problem presentation. Thus, they suggested that this model gives the opportunity to determine specific psychopathologies by identifying the certain phase of problem solving in which the inflexibility happens.

Barkley (1996, 1997) developed a perspective on executive function that derives from Bronowski's (1967, 1977; cited in Barkley, 1996) model of delayed responding in which inhibitory control is suggested to be the core mechanism underlying the basic four executive functions of the prefrontal lobes; namely *separation of affect*, *prolongation, internalization of speech* and *reconstitution*. By emphasizing Bronowski's assumptions, Barkley (1996) postulated that one must inhibit or delay his/her prepotent responses to initiate an executive behavior. *Separation of affect* refers to the capacity to inhibit immediate responding to environmental stimuli by separating informational content from emotional charge. The ability to remain silent despite intense feeling of anger requires separation of affect, for instance (Barkley, 1996). Brocki and Bohlin (2004) emphasized that one needs to regulate his or her emotions in order to maintain and complete a goal-directed behavior. Another EF is *prolongation,* which refers to the ability to form mental representations of events in order to retain them symbolically in mind that is much related to ‘working memory capacity’ (WMC) (Eslinger, 1996). The ability to resist other interfering stimuli is required for the maintenance of target information in working memory. Therefore, inhibition plays a key role for prolongation process as well. Regarding *internalization of language*, Barkley (1997) mentioned about Vygotzky’s (1978) theory on the development of private speech. Accordingly, as the language becomes mature, “it functions as a form of self guidance” (p. 70). This capacity is considered to be a consequence of inhibitory control as well because delay between stimulus and response provides an opportunity for “inner discussion of alternatives before a response is formed” (Barkley, 1997, p.70). The last EF within this model is r*econstitution,* which means generating new solutions, formulas and alternatives by analyzing or synthesizing events through delayed responding. It depends on prolongation and internalization of language, since mental representations are modified in the same manner with analyzing or synthesizing language while being kept active in working memory. Taken together, Barkley links these four executive capacities to behavioral inhibition and delay of responding, and he states that these four executive capacities make human behavior “intentional and purposive” (Brocki & Bohlin, 2004, p.573). Although Barkley’s theory is one of the aforementioned explanations for executive functioning in the literature, some researchers argue that this unifying perspective, which is based on inhibitory control, is insufficient to differentiate diverse components underlying the construct (Zelazo et al., 1997).

On the other hand, Roberts and Pennington (1996) proposed an interactive model through which they emphasize the interaction between working memory and inhibitory control processes underlying the executive functioning. According to this framework, two basic mechanisms are required for successful responding on most

EF tasks (e.g. the WCST, Tower of Hanoi, Stroop tasks): the ability to inhibit prepotent incorrect responses and then, to make a mental calculation to give the correct response. This 'mental calculation' capacity is considered to involve attentional activation, temporary storage of relevant information and computation (Roberts, & Pennington, 1996). For example, on the WCST, the subject has to inhibit the prepotent response; which is sorting the card by previously successful category (demand for inhibition). In addition, he has to retain feedback given for his previous response in order to determine correct response (working memory demand). Afterwards, Pennington et al. (1996) suggest that although working memory and inhibition can be considered as independent capacities in their model, it is possible to think that inhibition may be a component of working memory system by stating that "because working memory is a limited capacity system, inhibition (or interference control) is intrinsic to its operation" (Denckla, 1996, p. 266). Thus, from a two-factor model of executive functions, Pennington et al. (1996) came up with the conclusion that working memory is the basic capacity that all executive tasks have in common.

Based on this literature review, it can be concluded that there seems to be a general agreement that executive function refers to a higher-order, domain-general cognitive system that is responsible for the control, regulation and monitoring of lower-level functions, which is necessary for 'purposeful', 'future-oriented' behavior and goal-directed problem solving (Lezak, 1995). However, views regarding the nature of EF demonstrate a great deal of variety. For instance, while Barkley (1997) proposed that behavioral inhibition constitutes the basis for all areas of executive functioning from a unitary point of view, Roberts and Pennington (1996) contended the combination of inhibitory control and working memory as the core of EF. Others such as Lezak (1995), Zelazo et al. (1997) and Borkowski and Burke (1996) postulated many distinct but related steps of problem solving underlying the executive functions. Thus, the fundamental question seems to be whether there is one single underlying mechanism for executive functioning or whether it contains distinct subcomponents.

Researchers have conducted factor analytic studies to investigate whether the elusive nature of EF is unitary or not. They have consistently demonstrated three diverse but moderately related factors. Miyake, Friedman, Emerson, Witszki, Howerter, and Wager (2000) pointed out three executive functions as *(a) shifting between mental tasks, (b) updating and monitoring of working memory representations, and (c) inhibition of dominant or prepotent responses* after applying a set of executive tasks, including the WCST, to 137 college students. Bull and Scerif (2001) explored whether the results of factor analysis regarding the nature of EF conducted by Miyake et al. (2000) can be applied into children. In their study, they applied several executive measures, including the WCST, to 93 children with a mean age of 7 years, 4 months, and the regression analysis evidenced three factors as *(a) inhibition, (b) working memory* and *(c) perseveration* in predicting children's mathematic performance; seeming to support the three-factor model of EF proposed by Miyake et al. (2000). Yeniçeri and Atalay (2008) also explored factorial structure of executive functions measured by the WCST in a sample of four hundred forty-nine 8- to 11-year-old Turkish children. The findings indicated three factors as (*a) perseveration, (b) set maintenance* and *(c) conceptual thinking.* Thus, previous studies conducted in adult as well as child populations revealed that executive functions have a three-factorial structure although the results differ from study to study.

Working Memory Construct

The construct of working memory (WM) has a central position in several executive function models. As previously mentioned, working memory, involving the inhibition in itself, is considered the basic mechanism that all executive function tasks have in common according to Pennington et al. (1996). Barkley (1996, 1997) mentioned about WM while he discussed Bronowski's concept of prolongation. Presumably, it is a necessary underpinning for the stages of problem solving in the models that were proposed by Lezak (1995); Borkowsky and Burke (1996); and Zelazo et al. (1997).

The theoretical concept of WM is defined as a limited capacity system that is responsible for temporarily storing the task-relevant stimuli while simultaneously performing a cognitive task (Baddeley & Hitch, 1974; Daneman & Carpenter, 1980; cited in Miyake & Shah, 1999). Eslinger (1996) stated that

> The construct of working memory implies that certain information remains at the forefront of cognition despite distraction and hence active in the nervous system for the purpose of guiding appropriate responses, even when the stimulus configurations that gave rise to that information are no longer present."(p. 384).

Besides, he gave a hypothetical example to illuminate the reflections of impaired working memory. Accordingly, a patient with impaired WM sees an orange and a knife on the table, and starts peeling the orange in an automatic fashion. However, after peeling is completed, he leaves the orange on the table without a purpose of eating it or giving it to somebody else to eat. In other words, there is no aim or intention behind this action. "Although the apparent constraints of the situation are met, they (patients with impaired WM) do not necessarily imply an adaptive response that is of benefit to the organism." (Eslinger, 1996, p. 384).

Several models of WM exist in the field of cognitive psychology. Baddeley and Hitch (1974; cited in Baddeley & Logie, 1999) provided the first fractionable model of WM by decomposing it into three components, two ‘domain-specific’ slave systems; namely phonological loop and visuospatial sketchpad; and one ‘domain-general’ executive component; called as the central executive in their multi-component model. The *phonological loop* is responsible for storage of auditory or speech-based information. The *visuospatial sketchpad’* is claimed to involve two subsystems; one is called as *the visual cache* that retains visual patterns such as color and shape (Baddeley & Logie, 1999). The other subsystem, *inner scribe* keeps spatial information such as sequences of movement (Baddeley & Logie, 1999). The *central executive* functions as an attention-control system and coordinates activities of the other components.

Baddeley and Hitch (1974; cited in Baddeley & Logie, 1999) emphasized the “modality-spesific codes of representations” in working memory by proposing different formats of information that are held in the phonological loop and visuospatial sketchpad. Besides, different codes also exist in the visuospatial sketchpad as visual patterns are stored in the visual cache and spatial information is kept in the inner scribe. In this model, executive functions are managed by the central executive component of WM. Baddeley (2003) indicated that the central executive is “the most important but the least understood component of WM” (p. 835). According to him, the functions that are found not to be related with the storage systems are attributed to the central executive. Therefore, the central executive is treated as a homunculus, “a little person who makes all the awkward decisions in some unspecified way” (Baddeley & Logie, 1999, p. 39). To overcome these misunderstandings, Baddeley (1996) emphasized the fractional nature of the central executive listing its diverse functions as (a) to execute two tasks simultaneously, (b) to switch retrieval strategies, (c) to attend to one item and inhibit irrelevant stimuli, (d) to manipulate information coming from LTM, and finally (e) to update the content of WM according to newer input. Overall, he concludes that it is useful to consider the central executive as a unified system with multiple functions.

The fractionable nature of WM with multiple subsystems has been supported by other researchers. Oberauer, Suess, Wilhelm, and Witmann (2000) used exploratory and confirmatory factor analyses on 23 WM tasks in a sample of 128 young adults, and they found two dimensions as content and function among these measures. The first one involves verbal/numerical and figural/spatial material, which is considered to be consistent with the phonological loop and visuospatial sketchpad, suggested by Baddeley and Hitch (1974; cited in Baddeley & Logie, 1999). The functional dimension, on the other hand, contains three components; namely, "storage in the context of processing" (SP), "coordination / relational integration" (CO/RI) and "supervision" (SUP). Within this framework, Oberauer, Wilhelm, and Witmann (2003) defined "storage in the context of processing" as "retention of briefly presented new information over a period of time in which the information is no longer present" (p.169). This first function refers to the dual task capacity of WM, which means keeping task-relevant information active and accessible while performing a cognitive task at the same time. The second functional component "*relational integration*", which was previously called as 'coordination', is "the ability to build new relations between elements and to integrate relations into structures" (p.169). It is mentioned that coordination is mostly required in reasoning tasks, in which one has to form a mental image out of parts (Kosslyn, Reiser, Farah & Fliegel, 1983; cited in Oberauer et al., 2000). The *"supervision"* function involves “the monitoring of ongoing cognitive processes and actions, the selective activation of relevant representations and procedures, and the suppression of irrelevant, distracting ones” (p.169). It contributes to behavioral flexibility (Milner, 1963; cited in Oberauer et al., 2000), planning and goal directed behavior (Duncan, Emslie, Williams, Johnson & Freer, 1996; Shallice, 1982; Shallice &Burgess, 1991; cited in Oberauer et al., 2000). The supervision term, proposed by Oberauer and his colleagues (2003), seems to be similar to controlled attention managed by the central executive in the theory postulated by Engle, Kane, and Tuholski (1999).

Accordingly, Engle, Kane and Tuholski (1999) conceptualized WM as involving domain-free, limited capacity controlled attention capacity in addition to domain-spesific codes like phonological loop and visuospatial sketchpad. However, the potential number of such stores is greater than that Baddeley and Hitch (1974; cited in Baddeley & Logie, 1999) proposed. Engle, Kane and Tuholski (1999) viewed working memory as short-term memory (STM) plus controlled attention. The difference between WM and STM is a crucial point in their framework. Whereas STM capacity is described as a simple storage, WM is considered to consist of processing component as well as storage. Complex span tasks designed for assessment of WM demand both temporary storage and processing activity in contrast to STM or simple span tasks**;** in which participants are asked to recall digits or words presented one per second in a correct order (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002). The first valid measure of working memory capacity (WMC) was developed by Daneman and Carpenter (1980; cited in Engle et al., 1999), in which participants read or listen to a series of sentences and then recall the last word of each sentence. Engle, Tuholski, et al. (1999) examined the relationship between verbal-numerical STM and WM span tasks; and their relationships with fluid intelligence by latent variable analysis. The findings showed a moderate correlation (r = .68) between STM and WM tasks at the level of latent variables. They concluded that these two constructs are separable, proposing that WM includes "the contents of STM plus controlled attention" managed by the central executive (p. 310). Controlled attention; defined as the 'domain-free' process responsible for maintaining memory representations in the face of processing, distraction or interference, is claimed to be the major difference between STM and WM (Engle, Tuholski, et al. 1999). Therefore, WMC tasks demand more 'the central executive' processing or controlled attention than simple STM capacity tasks. In other words, "the more a task forces the participant to engage in controlled effortful processing rather than automatized skills, the more that task will tap WMC, and the less it will tap STM capacity" (Conway et al., 2002, p. 165). Conway et al. (2002) proposed that individual differences in working memory result from individual differences in controlled attention capacity. Engle, Tuholski et al. (1999), however, noted "tasks that are WM tasks for some people (e.g., children) might be primarily STM tasks (e.g., adults) for others, because of differential reliance on the central executive" (p. 327). Thus, developmental stages and individual differences seem to be crucial in terms of controlled attention capacity.

Although there seems to be disagreement on the number of different domain-specific codes and the characterizations of the subsystems, most theorists have postulated a framework with multiple components (Kintsch et al., 1999). Cowan (1999) also accepted the possibility of different domain-specific codes in WM such as auditory, visual and tactile. Yet, he did not propose distinct subsystems in his embedded-processes model of working memory. Rather, he emphasized that different types of modalities are processed with the same principles. Accordingly, encoding, maintenance and retrieval work similarly for each modality. (For instance, in each modality, most interference comes from stimuli of the same modality; which is called modality-specific interference). Whatever the modality is, working memory system uses three basic components: focus attention and awareness, activation, and long term memory. The system is organized in an embedded way; information in the current focus of attention is embedded within the subset of temporally activated memory, which is embedded within the long-term memory. The information in the current focus of attention is the most accessible information in working memory. Attending certain stimuli requires voluntary processes of the central executive. Information that is activated, but not in the focus of attention can also be accessed, however, it takes much time to be retrieved. Finally, inactive information in the long term memory is used if it is necessary for a task in working memory. Thus, working memory involves activated information of long-term memory. Cowan (1996) mentioned that “Most stimulus situations in life include novel combinations of familiar features. In memory, the elements are activated independently, but the particular links between those elements are often novel.” (p.89). Overall, WM involves both information in the focus of attention and information outside the focus of attention in this framework. As Cowan (1999) stated, “Rather than unattended stimuli being filtered out, all stimuli activate some elements of memory, but this process is enhanced for attended stimuli (or for stimuli that recruit attention).” (p. 78).

It seems that various theorists put forward different emphases in terms of nature and function of working memory in their models. Yet, the prominent role of working memory in complex cognitive systems and executive functions has been accepted by most of all. Miyake and his colleagues (2000) carried out a crucial study that supported the importance of WMC for intact executive functions. They administered a number of executive tasks to 137 college students and pointed out three distinct but related types of executive functions as (a) shifting, (b) updating/working memory, and (c) inhibition. The moderate to high correlations among the three executive functions ranging from .42 to .63 indicated that the shifting, updating and inhibition share some underlying commonality. One possible explanation they proposed is that the basic requirement necessary to achieve all nine executive tasks might be "maintenance of goal and context information in working memory" (p. 88). Accordingly, they concluded that working memory capacity might constitute the unity among the three executive functions mentioned above. Miyake and his colleagues' alternative explanation for the commonality among the three executive functions was that they all might share the process of inhibitory control to work properly. This second possible explanation seems to be parallel to Barkley's model of executive functions, in which he proposed that inhibitory control is the core mechanism underlying all executive functions. Bull and Scerif (2001) also supported the view that inhibitory processes can explain the unity among all executive functions. Overall, Miyake and his colleagues' two potential explanations for the unity among the executive functions appears to be compatible with the interactive model of executive functions proposed by Roberts and Pennington (1996), which states that both working memory and inhibitory control processes are required for executive functions. Over the last years, however, some researchers such as Pennington and his colleagues (1996) argued that inhibition is a part of working memory system rather than being an independent capacity. Miyake et al. (2000) also stated that

> Although this account is vague in terms of what the notion of "inhibition" really means, it deserves further investigation, given that the theoretical proposals that

> emphasize inhibition as a basic unit of working memory and executive control processes have become popular in the literature (p. 89).

The Relationship between Verbal and Visuospatial Working Memory

In the working memory literature, there seems to be a theoretical debate regarding the relationships among the components of working memory. There has been evidence regarding the dissociation of verbal and visuospatial WM tasks in the literature (Oberauer et al., 2000). Shah and Miyake (1996) also pointed out that the reading span task was found to be significantly correlated with verbal SAT (scholastic aptitude test) scores (.45), but not with spatial ability tests. Conversely, spatial WM span task was significantly correlated with spatial ability tests (.66), but not with verbal SAT score.

Kane et al. (2004), on the other hand, mentioned about the obstacles in interpreting the dissociation of verbal and spatial domains of WMC. First of all, they reported that the correlations between verbal and spatial WMC tasks are inconsistent across studies. The reading span (verbal WMC) and the rotation span (spatial WMC) developed by Shah and Miyake (1996) demonstrated the correlations with each other as .23 in Shah and Miyake's study (1996) and .42 in the study conducted by Friedman and Miyake (2000). Further, Kane et al. (2004) evidenced that verbal WM tasks show high correlations ranging from .49 to .60 with visuospatial WM tasks. More precisely, verbal and visuospatial WM tasks were found to share 70% of their variance by confirmatory factor analysis, reflecting that WM tasks measure domain-general capacity rather than domain-specific skills. In contrast, verbal and visuospatial STM tasks were found to have only 40% shared variance, indicating that

STM tasks reflect more domain-specific capacities. Overall, their findings seem to support a domain-general nature of working memory rather than dissociation between domain-specific modalities. To sum up, the evidence regarding the nature of working memory seems to be conflicting. On the one hand, some studies pointed to the separability between verbal and visuospatial working memory storages (Shah & Miyake, 1996). On the other hand, however, others demonstrated a more domain-general structure for the construct (Kane et al., 2004) emphasizing the role of the central executive component.

The Relation between Working Memory and General Fluid Intelligence

Although researchers have explored the relationship between WM and general fluid intelligence (*gf*) for more than one decade, they remain far from consensus (Yuan et al., 2006). "Fluid intelligence (*gf*) refers to the ability to solve novel problems and is putatively nonverbal and relatively culture free." (Horn & Cattell, 1967; cited in Engle, Kane, & Tuholski, 1999, p. 107). As opposed to crystallized intelligence (*gc*), which is suggested to depend on acquired knowledge through school-based learning and cultural background, *gf* is considered to be loaded on "nonverbal tests that require novel problem solving (e.g., Wechsler Block Designs, Raven's matrices, figural analogies), inductive reasoning, and short term memory for newly learned material (e.g., the backward digit span)" (Jensen, 2002, p. 47). The Raven's Standard Progressive Matrices (SPM, Raven, 1998) and Cattell's Culture Fair Test (CFT, Cattell, 1973) are considered as good measures of fluid intelligence (Yuan et al., 2006).

Friedman, Miyake, Corley, Young, DeFries, and Hewitt (2006) argued that distinct executive functions are differentially related to intelligence. They examined the relations of fluid, crystallized intelligence and Wechsler Adult Intelligence Scale (WAIS) IQ score to three separable executive functions; inhibiting, shifting, and updating in young adults. *gf* was measured by Raven's Progressive Matrices Test and Block Design subtest of the WAIS, and *gc* was assessed by Information subtest of the WAIS and a multiple choice vocabulary test. The WAIS IQ score was derived from 11 subtests scores. They reported that updating (working memory) is closely related to intelligence (.74 to fluid intelligence, .79 to crystallized intelligence) while inhibiting and shifting not. Thus, it seems that intelligence and executive functioning are related through working memory capacity.

Kyllonen and Christal (1990; cited in Engle et al., 1999) made the first latent variable analysis to investigate the relationship between WMC and *g*, and they asserted a very strong relationship (.80 to .90) between WMC and reasoning ability, which is considered a central aspect of *gf* (Carroll, 1989; cited in Engle, 1999). This considerable overlap between WM and reasoning measures led them to claim that "reasoning ability is (little more than) working memory capacity" (Kyllonen, 2002, p. 439). Then an ongoing debate has begun among researchers regarding whether WM and *gf* are same constructs or not. Ackerman, Beier and Boyle (2005) claimed that the true score of correlation between WM and *g* is only .48 after conducting a meta-analysis of 86 samples that relate WM to intelligence. As a reply, Oberauer, Shulze, Wilhem and Süss (2005) reanalyzed the data Ackerman et al. (2005) reported and found a very strong relationship (.85) between WM and *g* as parallel to Kyllonen and Christal. Colom, Flores-Mendoza, and Rebollo (2003) found a relationship between factor scores of working memory and intelligence ranging from .69 to .71 measured with the SPM by Raven and the letter series of the Primary Mental Ability Test (Thurstone, 1938). As mentioned above, Engle et al. (1999) also implemented structural equation modeling (SEM) to address whether STM and WM differentially relate to *gf* and they found a high loading (r = .59) of working memory on fluid intelligence measured with the CFT and the SPM. However, STM was not found to be a significant predictor of *gf*. Conway et al. (2002) confirmed these results by using the same *gf* measures (CFT and SPM). Thus, WM, but not STM, demonstrates a strong link to fluid intelligence.

As Buehner, Krumm and Pick (2005) noted, the more important question appears to be which components of working memory predict fluid intelligence. Engle et al (1999) and Conway et al. (2002) argued that after the variance common to STM and WM tasks are removed, the residual is attributed to 'controlled attention' function of the central executive, and the SEM analysis still revealed significant correlation to *gf* (.49). Therefore, they concluded that the connection between WM and *gf* is driven by 'controlled attention' component. Kane and Engle (2002) defined this concept as "a capability whereby memory representations are maintained in a highly active state in the presence of interference, and these representations may reflect action plans, goal states, or task-relevant stimuli in the environment" (p. 638). They emphasized that active maintenance of target information (1) and blocking mental or environmental distractors that might capture attentional focus (2) are two basic independent characteristics of executive attention that are primarily responsible for the relationship between WM and *gf* constructs. Kane and Engle (2002) suggested that the strong relationship between WMC, executive attention and fluid intelligence is supported by the evidence that they also share a neurological structure, prefrontal cortex (PFC) and particularly, dorsolateral PFC (dPFC). Although they mentioned about several difficulties arising from attempts to map WMC and *gf* onto the prefrontal cortex (PFC) due to anatomically complexity of PFC and its interconnectivity with other cortical and subcortical brain areas (Goldman-Rakic, 1987; cited in Kane and Engle, 2002), they speculated that intact dPFC structures are necessary to block distractors effectively for memory maintenance. Nonetheless, they made a caution that dPFC is critical for executive attention processes, but not sufficient on its own, indicating that various neurological structures might be also responsible for these processes.

Oberauer et al., (2008, in press) explored the correlation between three components of WM (storage in the context of processing, relational integration and supervision) and four factors of intelligence (reasoning, speed, memory, and creativity) in a sample of 135 university students. Their results showed that "storage in the context of processing" and "relational integration" components are significantly correlated with all four factors of intelligence. However, when they were entered into regression, only relational integration predicted intelligence (.71 for reasoning, .80 for speed, .64 for creativity) whereas the other two components of WM did not. The authors questioned the idea that the relationship between working memory and reasoning is driven by the central attention (Engle et al., 1999) since in this study, supervision; which was measured by task-set switching (mentioned as a prototypical executive-attention task) did not significantly correlate with reasoning. They argued that the common variance of WMC and reasoning mostly depends upon the ability to build a new mental representation between elements such as "seeing a constellation in a collection of stars" (p. 1). This is a very new theoretical account for the issue, so it seems to be open to debate for now. In any case, literature supports the relationship between working memory and fluid intelligence although "the variation in measurement, terminology, and statistical methods" might lead to inconsistent conclusions (Yuan et al., 2006, p. 91).

Apart from the relationship between WM and *gf*, some researchers investigated the correlation between the IQ and the EF test scores. The findings implied that these intelligence tests and executive measures assess different things although they overlap to a certain extent. Previous studies revealed that although patients with EF deficits perform poor performance on the WCST, they remain in the normal range of general intelligence measured by the WAIS (Alvarez & Emory, 2006). Arffa et al. (1998) applied the WISC-R (Wechsler Intelligence Scale for Children-Revised) and the WCST to above average (full scale IQs between 110-129) and superior (full scale IQs are above 130) children between 9 to 14 years. The findings of multiple regression analyses revealed that full-scale IQ scores are statistically related to four WCST scores; perseverative, nonperseverative, total errors and trials to complete the first category. Another study was conducted in 13- to 16-year-old adolescents by Ardila, Pineda and Rosselli (2000); which demonstrated that only perseverative errors of the WCST are significantly correlated with the WISC-R Verbal and Full Scale IQ scores. Seidenberg et al. (1983; cited in Arffa et al., 1998) reported that the relationship between IQ and EF performance might vary according to the complexity the EF measure. In their study, in which the WISC-R and Halstead-Reitan Neuropsychological Test Battery for Older Children were applied to one hundred and twenty 9-to 14-year-old children, simple motor or perceptual tests were found to be unrelated to IQ whereas more complex ones that require conceptual problem solving and mental flexibility demonstrate correlations with IQ tests.

Family Characteristics and EF Performance

Familial Characteristics

Literature provides considerable evidence for the association between socioeconomic status and cognitive ability during childhood, adolescence and even adulthood, although there is no consensus on what aspects of socioeconomic status are most critical for cognitive development (Bradley & Corwyn, 2002). Parental education, occupation and income are known as the most common measures of socioeconomic status (Bradley & Corwyn, 200). However, as Bornstein and Bradley (2003) state, in reality parents feel more comfortable reporting education and occupation-related information rather than their income (Noble, McCandliss, & Farah, 2007). Besides, the study carried out by Mercy and Steelman (1982) revealed that parental education was a stronger predictor than family income for verbal and nonverbal cognitive abilities measured by Wechsler Vocabulary and Block Design subtests, respectively, in a sample of 6- to-11-year-old children.

Noble et al. (2007) investigated the association between executive functions (working memory, inhibitory control and reward processing) and SES (parental education and occupation) in a sample of 150 first grade students. The findings revealed that both working memory and inhibitory control are associated with SES. Parental education and occupation together accounted for 6.1% of the variance of the working memory composite. Klenberg, Korkman, and Lahti-Nuutila (2001) also supported the relation between parental education and EF performance in Finnish children; however, they suggested that level of parental education is more strongly associated with multidimensional EF tasks such as Tower of Hanoi, which requires planning, working memory and problem solving at the same time than those assessing predominantly attention or behavioral inhibition.

Ardila, Rosselli, Matute, and Guajardo (2005) applied a number of executive function tests including Card Sorting Test (a simplified version of the WCST) to 5- to-14-year-old Mexican children. The findings demonstrated that parents' educational level was associated especially with the scores of verbal executive function tests rather than those of nonverbal ones. More specifically, no significant effect of parental education was found for the Card Sorting test in their study. In addition, they reported that the mean difference in the educational level between fathers and mothers was less than one year of education. Therefore, researchers argued that there might be "a home effect" rather than a "father" or a "mother" effect on the differences among children's EF performances. However, literature provides substantial evidence that mothers' education is primarily important for their children's cognitive abilities. For example, in Mercy and Steelman's (1982) study, mothers' education shows a considerably stronger effect on the nonverbal cognitive ability than father's education. Further, Yeniceri and Atalay (2008) pointed out that while mothers' education significantly predicted perseveration measured by the WCST in a sample of 449 Turkish children aged from 8 to 11 years, father's education did not.

Regarding occupation, previous studies mostly focused on mother's employment by categorizing mothers as working versus nonworking. Yet, Bradley & Corwyn (2002) mentioned that the findings are inconsistent regarding the relationship between mothers' occupational status and children's cognitive abilities. Desai, Chase-Lansdale and Michael (1989) indicated that the effects of mother's occupation on cognitive abilities are twofold. One the one hand, mother's occupation reduces the amount of time mothers spends with their children and hence their responsiveness. On the other hand, it contributes family income, therefore economical resources that are devoted to the child. In the literature, for instance, there is an argument that "what parents experience at work, they incorporate into their style of parenting" (Kohn & Schooler, 1982; cited in Bradley & Corwyn, 2002, p. 376). Consistent with this argument, Parcel and Menaghan (1990; cited in Bradley & Corwyn, 2002, p. 376) suggested that working mothers are able to provide "more stimulating materials… and problem solving opportunities" to their children as compared to nonworking mothers. On the other hand, Mercy and Steelman (1982) found that mother's occupation showed a negative relationship with children's verbal and nonverbal IQ scores. However, they also noted that mother's employment has an indirect positive effect on cognitive ability since it leads to less number of children at home. Overall, Desai et al. (1989) indicated that the effects of mothers' occupation on children's cognitive abilities might be complex, therefore its interactions with other family factors such as parental education or number of siblings must be explored in detail.

Socioeconomic status is considered to reflect many other family variables in addition to three common used SES variables mentioned above. Number of siblings is another crucial family factor that might influence children's cognitive abilities. Previous research provides consistent evidence that there is a negative relationship between number of siblings and cognitive performance of children. Mercy and Steelman (1982) demonstrated that both number of younger and older siblings are inversely related to the scores of Wechsler Vocabulary and Block Design subtests scores. Regarding executive functioning, Hughes and Ensor (2005) stated that number of siblings might possibly influence children's EF performance and its effects need to be explored further. In the study conducted by Shu et al. (2000) with 219 Taiwanese children reported a significant correlation between number of siblings and conceptual level response score of the WCST. Except Shu et al.'s study, the EF literature seems to be lacking studies that focus on the effects of number of siblings on EF performances.

Child Characteristics

Gender Differences

Previous studies have provided no evidence for gender difference on any of the WCST scores in Taiwan (Shu et al., 2000), Colombian (Rosselli and Ardila, 1993; Ardila et al., 2005) and Turkish children (Yeniçeri and Atalay, 2008).

Although previous research based on the WCST scores seems to be consistent regarding gender differences, the findings about the working memory are more complicated due to diversity of tests used to measure the construct. Brocki and Bohlin (2004) showed no sex differences for working memory capacity measured by digit span subtest of the WISC III in a sample of 92 children aged between 6 to 13 years. On the other hand, the meta-analyses in terms of sex differences on WM measured by mental arithmetic and digit span subtests of the WISC-R and the WPPSI pointed out gender difference in WM, indicating that males perform better in mental arithmetic while females perform better in digit span (Lynn & Irwing, 2008). Lynn and Irwing interpreted these findings in that digit span is in fact an immediate/STM task because even in the backward digit span, dealing with the first three and four numbers does not require processing but only storage. Thus, based on the findings of the mental arithmetic subtests, they concluded that there is a male advantage in working memory.

Maccoby and Jacklin (1974; cited in Strand, Deary & Smith, 2006) reviewed previous studies about sex differences on cognitive abilities that have been published since 1974. They concluded that there has been no consistent evidence for gender differences on composite scores of IQ tests. However, significant differences have been found regarding specific skills, implying that girls perform better on certain subtests whereas boys perform better on others. Maccoby and Jacklin (1974; cited in Strand et al., 2006) indicate that girls are more successful on verbal abilities while there appears to be a male advantage in quantitative and visuospatial abilities. On the other hand, Strand et al. (2006) applied CAT3 (Cognitive Abilities Test-third version; Lohman et al., 2001) in a sample of 11- to-12-year-old students in order to assess reasoning. The mean scores of verbal and nonverbal reasoning batteries for girls were higher than the mean scores for boys, whereas the mean scores of quantitative reasoning were higher for boys than those for girls. Irwing and Lynn (2005) did a meta-analysis on gender difference in reasoning ability. They reviewed 22 previous studies concerning gender differences on the Progressive Matrices, which is a well-established tool for assessing *g* factor (Jensen, 1998; cited in Irwing & Lynn, 2005). As opposed to previous studies, which suggested no sex differences on the Standard and Advanced Progressive Matrices in adults as well as children, they found a 4.6 to5 IQ point advantage for men.

Overall, literature has consistently revealed no gender differences on the WCST. However, the findings about working memory and reasoning tasks seem to be more complicated.

Age Variable

During recent years, the developmental aspects of EF have become the center of attention and that has led to an increase in the number of research focusing on executive functions in young children. As Blair, Zelazo, and Greenberg (2005) noted, the development of EF is particularly rapid during early years of life as opposed to the view that the frontal lobes are "functionally silent" during early childhood (Golden, 1981; cited in Anderson, 2001, p. 121). Espy (2004) emphasized that children are not only quantitatively but also qualitatively different from adults in EF performance. Brocki and Bohlin (2004) stated as follow:

> As Welsh and Pennington (1988) pointed out, by using adult-like performance as an indicator for executive functioning, one fails to capture the actual process of development in this domain. It may be that executive skills are involved in certain behaviors in childhood that are no longer evident in adulthood. Consequently, by focusing on the criterion of adult-like performance one may mask the development of executive functions of particular importance in childhood (p.572).

In addition, researchers have noticed the importance of executive functions for understanding developmental psychopathologies. There is a growing body of evidence reporting that EF play a critical role in many developmental disorders such as ADHD (e.g., Barkley, 1997; Shallice et al., 2002) and autism (e.g., Pennington & Ozonoff, 1996). This has prompted research focusing on the EF measures in young children. Many studies measuring the development of executive functions even in preschool period (in ages from 2 to 6 years) have been documented (e.g., Zelazo et al., 1997, Diamond, Carlson, Beck, 2005).

A number of studies have been published on the developmental trajectories of executive functions in childhood (e.g., Brocki & Bohlin, 2004; Klenberg et al., 2001). Generally, a progressive improvement in EF performance has been observed with increasing age and children's EF performance reaches adult level by the ages 10 to 15 (Chelune & Baer, 1986; Rosselli & Ardila, 1993). Several normative studies for the WCST have been published so far. Chelune and Baer (1986) reported normative data for the WCST with 6–to 12-year-old American children. Rosselli and Ardila (1993) applied the WCST to 5-to 12-year-old Colombian children. Similarly, Shu et al. (2000) conducted a normative study with 219 Taiwanese children aged from 6 to 11 years. Yeniçeri and Atalay (2008) presented developmental norms for 8-to 11-year-old Turkish children. The current study aimed to contribute to Turkish WCST norms by providing additional normative data from 6- to 7-year-old children.

The Present Study

The aims of the present study were to a) examine the relationship between executive functioning and working memory; b) investigate the relationship between verbal and nonverbal working memory capacities; c) explore the relationship between working memory and fluid intelligence; d) probe the effects of certain family and child characteristics on EF performance.

Working memory plays a key role in executive functioning. In some frameworks, WMC is proposed to be a subprocess underlying the EF construct (e.g., Roberts & Pennington, 1996). In others, working memory is depicted as a system, in which the executive functions are managed by its central executive component (e.g., Baddeley and Logie, 1999). From both perspectives, these two constructs overlap to a certain extent. Therefore, the first aim of this study was to explore the relationship between EF and WMC. As a well-established EF measure, the Wisconsin Card Sorting Test was used in order to assess executive functioning. Regarding the working memory capacity, two different tests, Digit Span Backward and Finger Windows were applied to measure auditory and visuospatial working memory capacities, respectively. The WCST scores were expected to be correlated with Digit Span Backward and Finger Windows subtest scores.

Working memory is defined as a processing, as well as a storage system (Conway et al., 2002). It is argued that although storages are specialized for domain-specific material, processing is managed by the central executive component of working memory system. Thus, encoding, maintenance and retrieval work similarly for different stimuli in a domain-general manner (Cowan, 1996). There is a growing body of evidence that although auditory and visuospatial working memory store different modalities, they have some shared variance since they depend on the same processing system (Oberauer et al., 2000; Kane et al., 2004). Based on these findings, the present study predicted a moderate level correlation between Digit Span Backward and Finger Windows scores.

There has been an ongoing debate concerning the relationship between working memory and fluid intelligence in the literature. Some researchers claimed that these constructs are identical (e.g., Kyllonen & Christal, 1990; cited in Engle et al., 1999). Others, on the other hand, argued that they are distinct but related constructs (e.g., Ackerman et al., 2005). Hence, the third aim of the present study was to examine the relationship between WMC measured by Digit Span Backward and Finger Windows subtests, and fluid intelligence assessed by nonverbal reasoning battery of CogAT®.

The final purpose of the study was to explore the effects of certain family and child characteristics on EF performance. Literature provides considerable evidence for that cognitive performance and executive functions are associated with parental education (e.g., Noble et al., 2007; Ardila et al., 2005) and number of siblings (Mercy and Steelman, 1986; Shu et al., 2000). In the present study, since a high correlation was found between mothers' education and father's education, mothers' education was taken as the representative of parental education. Although literature points out that mother's employment might influence children's cognitive capacities in relation with parental education and number of siblings, its effects on the scores could not be explored in this study due to small sample size. Thus, the study has focused on the two family characteristics: mothers' education and number of siblings.

In addition, gender and age-related differences on EF performance were investigated in this study. Previous research has evidenced that boys and girls do not significantly differ on the WCST performance (Ardila et al., 2005; Yeniçeri & Atalay, 2008). However, the findings seem to be more complicated for working memory and fluid intelligence constructs due to the diversity of the instruments and the sample (children vs. adults). In this study, the focus was to examine whether girls significantly differ from boys on executive functioning (the WCST), working memory capacity (Digit Span Backward and Finger Windows) and fluid intelligence (the CogAT®-Nonverbal Battery) performances. Besides, the EF research has changed its focus from adult population to children during the recent years. Many researchers have studied the measurement of executive functions in young children (e.g., Zelazo et al., 1997; Klenberg et al., 2001). Thus, another aim of this study was to examine whether 6- to-7-year-old children are able to show complex executive capacities required by the WCST. As previous research has evidenced, these capacities improve as the children's age increases (e.g., Brocki & Bohlin, 2004; Klenberg et al., 2001). Therefore, 6-year-old children's EF performance was also compared with that of 7-year-old ones.

Overall, this study specifically aimed to explore

a) the relationship between the WCST and the two working memory capacity tasks, which are Digit Span Backward and Finger Windows;

b) the relationship between the auditory (Digit Span Backward) and the visuospatial (Finger Windows) WMC tasks,

c) the relationship between the WMC tasks (Digit Span Backward and Finger Windows) and the fluid intelligence test (the CogAT®-Nonverbal Battery),

d) the effects of certain family characteristics, which are mothers' education and number of siblings on the scores of the WCST, Digit Span Backward, Finger Windows tests and the CogAT®-Nonverbal Battery,

e) the gender and age-related differences on the scores of the WCST, Digit Span Backward, Finger Windows tests and the CogAT®-Nonverbal Battery.

CHAPTER II: METHOD

Sample of the Study

The participants were eighty-nine (45 male and 44 female) 6-to 7-year-old Turkish children recruited from five (two private and three public schools) primary schools in İstanbul. The ages ranged from 6.2 to 7.7 with a mean of 6.10. No child was reported to have a neurological disorder. The sample included 77 right-handers and 12 left-handers.

Instruments

Demographic Information Form

Demographic data about children's age, gender, number of siblings, parental educational level and occupation were obtained through a demographic questionnaire. In addition, parents were asked to indicate whether their children had a medical problem or not. A copy of the form is presented in the Appendix B.

Wisconsin Card Sorting Test (WCST)

Wisconsin Card Sorting Test (WCST) is a well-established neuropsychological instrument. It was originally developed by Berg (1948) as a measure of abstract thinking and mental flexibility (Berg, 1948) for research purposes. After years, Heaton (1981) standardized it for clinical use. Today, '*the Heaton version'* is the most commonly used model of the WCST (Alvarez & Emory, 2006). Initially, the WCST was designed for adult populations (Berg, 1948). The first study that provided developmental norms for the WCST in normal sample was conducted by Chelune and Baer (1986; as cited Franzen, 2000) from one hundred and five 6- to 12-year-old children. In this study, it was reported that 10-year-old children showed the same level of performance with adults. Heaton, Chelune, Talley, Kay and Curtis (1993; cited in Franzen, 2000) updated the manual for the WCST by including additional developmental norms from 6 years-old to adulthood.

WCST consists of four reference cards, which vary according to three dimensions: the number of objects on the card, the shape of objects and their color. Participants are given 128 cards, which also vary along the same three dimensions, and they are asked to place each card below one of the four reference cards. The examiner says the word *right* or *wrong* after each card. The sorting strategy is not revealed to the participant. The color is the first sorting category. The participant is given positive feedback if s/he places the first card below the reference card of the same color. After 10 consecutive cards are placed correctly, the sorting category is changed, without warning or comment by the examiner, to shape, and then to number, and repeats in the same order. This test ends after all 128 cards are placed by the participant.

WCST has the following scores; (1) total correct responses, (2) total errors, (3) perseverative responses, (4) perseverative errors, (5) nonperseverative errors, (6) conceptual level responses, (7) number of categories completed, (8) number of trials to complete the category, (9) failure to maintain set, (10) learning to learn, (11) trials administered. Heaton (1981) indicated that the score with the most diagnostic utility is the perseverative response score. A perseverative response is defined as a response that has been correct in the previous category, but it is no longer correct in the current category. For example, the first sorting principle of the test is color and subjects are expected to sort cards in terms of color on 10 consecutive times during the first stage of the test. If it is correctly done, the sorting principle changes into shape. Therefore, if a subject continues to place cards according to color instead of shape, he starts to give perseverative responses.

A computerized version of the WCST was used in this study. Artiola I Fortuny and Heaton (1996; cited in Franzen, 2000) compared the computerized version and the standard format of the test in normal subjects and they suggested that there are no performance differences between these two versions. Tien et al. (1996; cited in Shu et al., 2000) supported these findings by arguing that there are no significant differences on the scores of '*perseverative responses'*, '*perseverative errors'*, and '*the number of correct responses'* across the two formats. They indicated that the computerized version may be more reliable due to the fact that it eliminates the variability in presentation, feedback and recording of the scores in the manual version. Ozonoff et al. (1999; cited in Tsuchiya, Oki, Yahara, & Fujieda, 2005) also mentioned that the computerized version of the WCST is more advantageous, especially for patients with autism, because it requires less verbal demands than the standard version. Overall, the administration of the computerized version of the WCST was reported to be easier that it eliminates probable errors that might stem from the administrator.

Reliability

Franzen (2000) reported that the reliability of the WCST has not been studied in detail so far. He reminds the assumption about the test that repeated exposure may lead to a significant practice effect due to increased familiarity to the test material. Tate, Perdices, and Maggiotto (1998; cited in Franzen, 2000) investigated test-retest reliability of the WCST in a sample of people with traumatic brain injury (TBI) and in a sample of control subjects. The findings indicated that after an interval of 9 months, control subjects showed stability whereas TBI patients demonstrated improvement. Ingram, Greve, Ingram, and Soukup (1999) supported the high test-retest reliability of the WCST in an untreated patient sample with obstructive sleep apnea (OSA) and they reported that the 11 WCST scores ranged from .34 to .83 with a mean of .64. Lezak (1995) reported that interscorer and intrascorer reliabilities of the WCST are .88 and .96, respectively.

Validity

With regard to the construct validity of the WCST, Greve, Ingram, and Bianchini (1998) examined the consistency among four 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; cited in Greve et al., 1998) in the literature. They reported that most of these studies revealed two consistent factors; which are (factor I) *concept formation/perseveration* and (factor II) *failure-to-maintain set (FMS).* However, in their own study; in which sample was provided retrospectively from 467 clinical files of patients, Greve et al., (1998) found a third factor; '*nonperseverative errors' (NPE)* in addition to previously reported two factors by using principal components analysis. Koren et al. (1998) also indicated three factors, namely *perseveration, failure to maintain set* and *idiosyncratic sorting* for the WCST in a sample of patients with schizophrenia and in a sample of control subjects. The results of their study also showed that only perseveration seems to differentiate schizophrenic patients from controls. The study conducted by Greve, Love, Sherwin, Mathias, Ramzinski, and Levy (2002), in a sample of patients with chronic severe traumatic brain injury, supported the three-factor solution: *cognitive flexibility,* *problem solving* and *response maintenance*. Greve, Stickle, Love, Bianchini, and Stanford (2005) reviewed 17 explanatory factor analytic (EFA) studies of the WCST and they reported that there seem to be three cognitive processes including the *ability to shift set, problem solving/hypothesis testing and response maintaining* underlying performance of the WCST. In their own study, Greve et al. (2005) used a confirmatory factor analysis in a mixed sample of 1221 neurological and normal subjects to investigate factorial structure of the WCST. Their results also supported the three-factor model of the WCST. Yeniçeri and Atalay (2008) examined the internal validity of the WCST in a sample of 8- to 11-year-old Turkish children with exploratory factor analysis, and they found three factors as *a) conceptual thinking, b) perseveration, c) set maintenance,* which seems to be consistent with previous studies.

The Digit Span subtest of the Wechsler Intelligence Test for Children-Revised (WISC-R)

The Digit Span subtest of the WISC-R (Wechsler, 1992/1994; cited in Şavaşır & Şahin, 1995) is a verbal memory test, in which the examiner reads a series of digits with a speed of 1 sec per digit and then s/he asks the child to repeat each digit in the same order (Digit Span Forward) or in the opposite order (Digit Span Backward). The digit clusters range from two digits to nine digits. Both forward and backward subtasks consist of seven trials. In each trial, the child is asked to repeat two different attempts. If s/he repeated the two attempts correctly, 2 points are given and if s/he can repeat one of the attempts correctly, 1 point is given. The subtask is terminated when the child fails to repeat both attempts of a trial correctly.

The child has to use the capacity of holding oral material in mind in delay intervals in order to achieve both subtasks. On the Digit Span Backward (DSB) subtask, s/he should also keep the material active in mind and organize it for repeating the digits in the opposite order. This ability is assumed to be involved in working memory capacity since it requires ‘simultaneous storage and transformation’, which means reordering the digits while keeping them active in mind at the same time (Oberauer et al., 2000).

Reliability

With regard to test-retest and split-half reliability of the Digit Span, empirical data demonstrated .73 and .85, respectively. The g loading of the test seems to be moderate (.47) (Kaufman, 1994).

The Finger Windows subtest of the Wide Range Assessment of Memory and Learning

Wide Range Assessment of Memory and Learning (WRAML) was constructed as a comprehensive measure of memory and learning on a normative data of 2363 children between 5 and 17 years by Sheslow and Adams (1990). WRAML has nine subtests (Picture Memory, Design Memory, Verbal Learning, Story Memory, Finger Windows, Sound Symbol, Sentence Memory, Visual Learning and Number/Letter Memory) that were developed to measure unique abilities of memory. These nine subtests are combined to provide a General Memory Index. Sheslow and Adams (1990) suggest three factors for WRAML including a verbal memory, a visual memory and a learning index. The verbal memory index contains Story Memory, Sentence Memory and Number/Letter Memory subtests. The visual memory index consists of Picture Memory, Design Memory and Finger Windows subtests. The learning index is a composite of Verbal Learning, Visual Learning, and Sound Symbol subtests.

Finger Windows (FW) subtest is a visuospatial memory test; in which the examiner asks the child to imitate meaningless spatial sequences on the card, which has openings like windows. The examiner puts her pencil into one window and then another and then she asks the child to do the same thing. The length of the sequences increases across trials. 1 point is given for each correct sequence and the test is terminated after three consecutive errors.

Reliability

Coefficient alpha measures of internal consistency of WRAML subtests range from .78 to .90. The General Memory Index coefficient alpha was .96 and visual memory, verbal memory and learning indices range from .90 to .93. Spesifically, the median coefficient alpha for the Finger Windows subtest is .81. Test-retest reliability for General Memory Index is .84, and .82, .61 and .81 for verbal memory, visual memory and learning indices, respectively. The interscorer reliability obtained by randomly selected 82 cases from normative sample was found to be .996. (Sheslow & Adams, 1990).

Validity

Sheslow and Adams (1990) compared the performance of students on the WRAML to the McCarthy Memory Index (ages 6 and 7), the Memory Scale on the Stanford-Binet: Fourth Edition (ages 10-11), and the Wechsler Memory Scale-Revised, WMS-R (ages 16 and 17) to examine the concurrent validity of the

WRAML. The correlations between McCarthy Memory Index and WRAML indices range from .48 (visual memory index) to .90 (verbal memory index). Only the WRAML Learning memory index seems to be correlated with McCarthy Memory Index. The relationship between WRAML and Stanford-Binet Short Term Memory Scale appears to be also high, ranging from .67 to .80. WRAML seems to be moderately correlated with the WMS-R (.32 to .63) (Sheslow &Adams, 1990)

With regard to construct validity, the principal component analysis in the WRAML Index demonstrated three separate factors as verbal memory, visual memory and learning divisions. Finger Windows subtest has a statistically significant correlation with the visual memory factor (.66). Burton, Mittenberg, Gold, and Drabman (1999) examined the validity of the WRAML Manual Indices by using structural equation analysis. The results supported the three-factor model including verbal memory, visual memory and attention/concentration. They claimed that the empirical data failed to support learning index as a distinct factor. Instead, Finger Windows, Number/Letter and Sentence Memory subtests were found to be correlated with common measures of 'attention'. Thus, their results showed that Finger Windows loaded on both attention and visuospatial/nonverbal memory factors.

The Nonverbal Battery of Cognitive Abilities Test (CogAT®), Form 5

Form 5 of the CogAT® includes a series of tests designed by Thorndike and Hagen (1996) to evaluate the level of specific cognitive abilities of students from kindergarten to grade 12. The test was constructed based on Cattell's (1987; cited in Thorndike & Hagen, 1996) fluid-crystallized (*gf-gc*) abilities model and Vernon's (1961; cited in Thorndike & Hagen, 1996) hierarchical model of intelligence. In both models, the factor *g* or general (overall) reasoning skills are considered to be very crucial for learning and problem solving (Thorndike & Hagen, 1992).

The CogAT® has three different batteries as verbal, quantitative and nonverbal. The first two batteries are designed to assess abilities developed through schooling and acculturation called as 'crystallized intelligence' in Cattell's model and 'verbal educational abilities' in Vernon's framework. The Nonverbal Battery, on the other hand, measures general abstract reasoning skills that are mentioned to be less influenced by schooling and culture (Thorndike and Hagen, 1996). Engle et al. (1999) indicated that tasks consisting of geometric shapes and other nonverbal symbols are good measures to assess *gf*.

In this study, only the Nonverbal Battery (CogAT®-NB) was used with the aim of assessing fluid abilities. It consists of two subtests, namely Figure Classification and Matrices. In the Figure Classification subtest, the three figures are presented to students, whom are asked to think about essential similarities among these figures and to determine best answer that would fit the set among four choices. In the Matrices subtest, there is a four-cell matrix. Three cells of the matrix have some figures, however, the fourth cell at the lower right corner is empty. Participants are asked to place the most suitable figure into this empty cell by selecting among four choices. The score of the CogAT®-Nonverbal Battery was calculated by adding the score of Figure Classification test to that of Matrices test.

Reliability

Internal consistency coefficients were .97 for the CogAT® composite score; .79, .97 and .97 for Verbal, Quantitative and Nonverbal batteries scores, respectively (Alp and Diri, 2003). Blumen-Pardo (2002) also studied the reliability of the

CogAT® by applying the test to 213 second grade students in Peru. The internal consistency coefficients calculated by Kuder Richardson 20 (K-R 20) analyses were .75 for Verbal Battery, .82 for Quantitative Battery and .87 for the Nonverbal Battery; and .91 for the CogAT® composite score.

Validity

Alp and Diri (2003) assessed the construct validity of the CogAT® in a sample of 45 kindergarten and 360 first grade Turkish students. The CogAT® composite scores predicted students' current grade averages, r (16) =.63; p <.02 and their performance on the achievement test given by their school administration, r (37) = .68, p <.001 that provides evidence for the concurrent validity of the test. Further, Alp and Diri (2003) obtained information about grade averages of students whom received the CogAT® at first grade and at kindergarten after three years. The findings revealed that the CogAT® composite score predicted achievement of participants tested at grade 1, r (177) =.50, p <.001 as well as for those tested at kindergarten, r (14) =.65, p <.02 three years later, which demonstrates the predictive validity of the CogAT®.

Procedure

The researcher obtained the written permission of the Turkish Republic National Education Department (NED) to conduct this research at randomly selected elementary schools in Istanbul, Turkey. Following this step, contacts were arranged with schools that are planned to be included in the sample. Administrations were carried out on school grounds during class hours.

The researcher obtained informed consent from all parents for their children's participation in the research. Consent Forms and Demographic Information Forms were sent to families two weeks before the administrations. The copies of the Consent Form and the Demographic Information Form are presented in Appendix A and Appendix B, respectively.

The instruments were applied to children in two phases. In the first phase, each child was administered individually. The tasks were applied in the following standardized order: Wisconsin Card Sorting Test (WCST), Digit Span Backward (DSB) and Finger Windows (FW). In the second phase, children were given the CogAT®-Nonverbal Battery (CogAT®-NB) at a group session. Testing process lasted approximately for 40 minutes, which corresponds to one class hour. Before the testing, the examiner told that there is no time limit on any task, so participants were encouraged to think well and make correct responses as many as possible. The examiner gave a standardized instruction and no more guidance was revealed during the assessment. Each child received a small gift (a pencil) for his or her participation in the study.

CHAPTER III: RESULTS

Descriptive Characteristics of the Sample

The ages of the participants ranged from 6.2 to 7.7 years. The sample was categorized as 6-year-old and 7-year-old children in terms of age (Table 1). Thus, the first group (6-year-old children) includes children aged between 6.2 years and 6.11 years with a mean age of 6.7 years. The second group (7-year-old children) consists of those aged from 7.0 to 7.7 years with a mean age of 7.2 years. Frequencies in terms of ages and gender are given in Table 1.

Table 1

Frequency Distributions according to Age and Gender

		Gender		
		Female	Male	Total
Age	6-year-old	26	26	52
	7-year-old	18	19	37
	Total	44	45	89

The information regarding parental education was obtained from the Demographic Information Form (DIF). Parents were categorized into low, middle and high education groups according to their education level. Parents who gave up their education before completing the primary school (literate parents) and those who completed primary education of 8 years were grouped into "*low education group*". '*Middle education group'* includes parents with a high school degree and *'high education group'* involves parents with a university or graduate degree (master or doctorate). Regarding number of siblings, the sample was divided into three groups as children with no siblings, children with one sibling, and children with two or more siblings for the statistical analyses. There were only four children who had more than two siblings in the sample; three of them had 3 siblings and one child had 5 siblings. These children were grouped as the *'2 and more siblings'* group for the statistical analyses. The frequency distributions in terms of mothers' education and number of siblings are presented in Table 2.

Table 2

Cross tabulation of Mothers' Education Level x Number of Siblings

		Number of siblings			
		0	1	2	Total
Mother's educ level	Low	6	18	12	36
	Middle	7	8	5	20
	High	12	18	3	33
	Total	25	44	20	89

Method of Analysis

Only raw scores were used in the statistical analyses. The means, standard deviations, minimum and maximum values of the test scores (the WCST, Digit Span Backward, Finger Windows and the CogAT®-Nonverbal Battery scores) are displayed in Table 3.

Table 3

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

The scores	M	SD	Min	Max	N
WCST-TA	126.9	5.05	98	128	89
WCST-TC	56.88	18.31	23	99	89
WCST-TE	70.02	20.17	19	105	89
WCST-PR	33.97	18.66	8	100	89
WCST-PE	30.7	15.52	6	85	89
WCST-NE	40.1	19.11	11	85	89
WCST-CLR	37.51	23.39	0	92	89
WCST-CC	2.02	1.86	0	6	89
WCST-TC1st	61.37	46.33	10	129	89
WCST-FMS	1.16	1.33	0	5	89
DSB score	2.92	1.6	0	6	89
FW score	9.65	3.83	2	17	89
COGAT®-NB score	23.2	7.44	4	39	89

Note. WCST: Wisconsin Card Sorting Test, TA:Trials administered , TC: Total corect responses, TE: Total errors, PR: Perseverative responses, PE: Perseverative errors, NE: Nonperseverative errors, CLR: Conceptual level responses, CC: Categories completed, TC1st: Trials to complete the first category, FMS: Failure to maintain set, LL: Learning to learn, DSB: Digit Span Backward, FW: Finger Windows, CogAT®-NB: the nonverbal battery of CogAT®.

Correlations

First of all, Pearson product-moment correlation coefficients were calculated to examine relationships among the scores. The DSB score was found to be significantly correlated with five scores of the WCST that are total correct responses (TC), r (87) = .24, p < .05; total errors (TE), r (87) = -.25, p < .05; conceptual level responses (CLR), r (87) = .27, p < .05; number of categories completed (CC), r (87) =.36, p < .01; and trials to complete the first category (TC1st), r (87) = -.32, p <.01. The FW was correlated with the nonperseverative errors score (NE) of the WCST in addition to the five scores mentioned above, (TC) r (87) = .24, p < .05; (TE) r (87) = -.23, p <.05; (CLR) r (87) = .25, p < .05; (CC) r (87) =.31, p < .01; (TC1st) r (87) = -.22, p <.05; (NE) r (87) = -.22, p < .05. The relationship between the DSB and the FW scores was found to be .33 (p < .01).

The findings also demonstrated that the CogAT®-NB score is significantly related with the DSB, r (87) = .51, p < .01 with the FW, r (87) = .43, p < .01 scores as well as six scores of the WCST that are ‘total correct responses’, r = .41, p < .01; ‘total errors’, r = -.42, p <.01; ‘nonperseverative errors’, r = -.33, p < .01; ‘conceptual level responses’, r = .46, p <.01; ‘number of categories completed’, r = .44, p < .01; and ‘trials to complete the first category’, r = -.24, p < .05. The correlation coefficients are illustrated in Table 4.

Table 4

Correlation Matrix for the Measures of the Study

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. WCST-TA	1													
2. WCST_TC	-.249*	1												
3. WCST_TE	.476**	-.970**	1											
4. WCST-PR	.257*	-.356**	.388**	1										
5. WCST-PE	.280**	-.447**	.476**	.869**	1									
6. WCST-NE	.284**	-.725**	.729**	-.342**	-0,162	1								
7. WCST-CLR	-.323**	.980**	-.970**	-.384**	-,475**	-.706**	1							
8. WCST-CC	-.466**	.839**	-.878**	-.286**	-,363**	-.679**	.877**	1						
9. WCST-TC1st	.210*	-.681**	.671**	.021	0,117	.675**	-.695**	-.739**	1					
10. WCST-FMS	.073	.583**	-.511**	-.283**	-,304**	-.329**	.579**	.228*	-.229*	1				
11. WCST-LL	.032	.127	-.107	.035	0,002	-.12	.084	.051	-.071	-.02	1			
12. DSB	-.103	.243*	-.247*	-.055	-0,066	-.205	.266*	.362**	-.320**	-.005	.103	1		
13. FW	-.049	.243*	-.233*	-.009	-0,079	-.221*	.253*	.308**	-.216*	-.007	.111	.325**	1	
14. CogAT®-NB	-.171	.409**	-.414**	-.114	-0,134	-.328**	.453**	.439**	-.244*	.177	.096	.508**	.431**	1

Note. *p < .05, **p < .01 (two tailed). WCST: Wisconsin Card Sorting Test, TA:Trials administered , TC: Total correct responses, TE: Total errors, PR: Perseverative responses, PE: Perseverative errors, NE: Nonperseverative errors, CLR: Conceptual level responses, CC: Categories completed, TC1st: Trials to complete the first category, FMS: Failure to maintain set, LL: Learning to learn.

Multivariate Analysis of Variance (MANOVA)

Secondly, a 3 x 3 (mothers' education x number of siblings) multivariate analysis of variance (MANOVA) was applied to explore the effects of these family variables on the scores. Mothers' education was used as the representative of parental education due to the strong correlation, r (87) = .83, $p < .01$ between maternal (M_1 = 11.36, SD_1 = 3.68 in years) and paternal education (M_2 = 11.82, SD_2 = 3.39 in years). Main effects and interactions were analyzed. Partial eta squares (η^2) were calculated to estimate the effect sizes for *F* values. MANOVA results for significant *F* values are illustrated in Table 5.

The main effect of mothers' education was found to be significant for 'total correct responses', 'total errors', 'conceptual level responses', 'number of categories completed' and 'perseverative errors' scores of the WCST. Number of siblings, on the other hand, was significant for 'total correct responses', 'total errors', 'conceptual level responses', 'nonperseverative errors' and 'trials to complete the first category' scores of the WCST. The findings also show that whereas mothers' education significantly influences the DSB, the FW, and the CogAT-NB scores, number of siblings does not have a significant effect on these scores. The interaction between mothers' education level and child's number of siblings was not significant for any of the scores

Table 5

MANOVA Results

	Mother's educ		No of Sib		Mother's Educ x No of Sib	
Test scores	*F*	η^2	*F*	η^2	*F*	η^2
WCST-TC	4.74*	.106	3.83*	.087	.535	.026
WCST-TE	5.12*	.113	3.89*	.089	.462	.023
WCST-PE	3.23*	.075	0.20	.005	.946	.045
WCST-NE	1.19	.029	3.43*	.079	.601	.029
WCST-CLR	4.92*	.11	4.48*	.101	.415	.02
WCST-CC	3.94*	.09	2.90	.068	.423	.021
WCST-TC1st	2.00	.048	3.33*	.077	1.867	.085
DSB	8.73**	.179	1.79	.043	1.341	.063
FW	9.55**	.193	0.98	.024	1.646	.076
CogAT®-NB	6.25**	.135	1.90	.045	0.794	.038

Note. *p < .05, **p < .01. WCST: Wisconsin Card Sorting Test, TC: Total correct responses, TE: Total errors, PE: Perseverative errors, NE: Nonperseverative errors, CLR: Conceptual level responses, CC: Categories completed, TC1st: Trials to complete the first category, DSB: Digit Span Backward, FW: Finger Windows, CogAT®-NB: CogAT®-the nonverbal battery

Post hoc analyses were performed using Scheffe test to make comparisons among groups for significant F values ($p < .05$). Overall, a glance at the mean scores revealed that children's performance on the tests improve, as the mothers' education level increase. The means and standard deviations for significant F values of mothers' education level are displayed in Table 6. Children of mothers with high education level made more total correct responses, more conceptual level responses, completed more categories, made less total errors and less perseverative errors on the WCST than those of mothers with low education levels. However, the middle group did differ from neither the low nor the high group at a statistically significant level on these scores. Moreover, children of mothers with high ($p < .01$) and middle ($p < .01$) education levels performed better than children of mothers with low education on the

DSB and the FW tasks. However, the middle and the high groups did not differ from each other at a statistically significant level on the scores of the DSB ($p = .89$) and the FW ($p = .49$). Finally, on the CogAT®-NB score, children of mothers with high education performed significantly superior to those of mothers with middle ($p < .05$) and low ($p < .001$) education levels. Children's performance in the low group did not differ from that of children in the middle group ($p = .077$).

Regarding number of siblings, singletons were more successful than children with two siblings, who were more successful than children with one sibling on the following WCST scores: total correct responses, conceptual level responses, total errors, nonperseverative errors, and trials to complete the first category. Although the mean differences between singletons and children with one sibling were at the statistically significant level ($p < .05$) on all of these scores, the mean differences between singletons and children with two or more siblings did not reach a statistically significant level on 'total correct responses' ($p = .08$), 'nonperseverative errors' ($p = .24$), and 'trials to complete the first category' scores ($p = .09$). The means and standard deviations for significant F values of number of siblings are displayed in Table 7.

Table 6

Posthoc Comparisons for Significant F Values of Mothers' Education Level

Test scores	Mother's educ level	M	SD	N
	low	50.31	16.81	36
WCST-TC	middle	56.45	14.37	20
	high	64.33	19.6	33
	low	77.47	17.22	36
WCST-TE	middle	71.55	14.37	20
	high	60.97	22.87	33
	low	34.83	18.93	36
WCST- PE	middle	29.45	9.58	20
	high	26.94	13.45	33
	low	28.47	21.75	36
WCST- CLR	middle	37.50	15.83	20
	high	47.36	25.42	33
	low	1.28	1.75	36
WCST- CC	middle	2.15	1.23	20
	high	2.76	2.03	33
	low	1.97	1.73	36
DSB	middle	3.45	1.28	20
	high	3.64	1.06	33
	low	7.25	3.19	36
FW	middle	10.6	3.59	20
	high	11.7	3.19	33
	low	19.06	6.74	36
COGAT®NB	middle	23.3	6.97	20
	high	28.09	5.91	33

Note. WCST: Wisconsin Card Sorting Test, TC: Total correct responses, TE: Total errors, PE: Perseverative errors, CLR: Conceptual level responses, CC: Categories completed, DSB: Digit Span Backward, FW: Finger Windows, COGAT®NB: The nonverbal Battery of the CogAT®.

Table 7

Posthoc Comparisons for Significant F Values of Number of Siblings

Dependent Variables	Number of siblings	M	SD	N
	0	66.2	15.56	25
WCST- TC	1	52.77	18.73	44
	2	54.3	17.09	20
	0	59.2	18.78	25
WCST-TE	1	74.52	20.25	44
	2	73.65	17.18	20
	0	31.52	12.85	25
WCST-NE	1	44.61	21.33	44
	2	40.9	17.59	2
	0	50.64	19.37	25
WCST-CLR	1	31.86	23.92	44
	2	33.5	21.15	20
	0	37.72	30.05	25
WCST- T1stCat	1	72.89	48.57	44
	2	65.6	49.04	20

Note. WCST: Wisconsin Card Sorting Test, TC: Total correct responses, TE: Total errors, NE: Nonperseverative errors, CLR: Conceptual level responses, TC1st: Trials to complete the first category.

Regression Analyses

Hierarchical multiple regression analyses were conducted to examine how well the family variables (mothers' education in years and number of siblings) predicted the WCST, the DSB, the FW and the CogAT®-NB scores. The analyses were done for the following scores of the WCST: total correct responses, perseverative errors, conceptual level responses, and categories completed; which were found to be affected by independent variables (mothers' education and number of siblings) in the MANOVA analyses. The independent variables were entered into the equation as follows: mothers' education in years, number of siblings. The results are presented in Table 8.

When mothers' education in years entered as the only independent variable, it predicted WCST-total correct responses, $\beta = .323$, $p = .002$. When the number of siblings variable was entered into the equation, mothers' education still predicted the WCST-total correct responses scores, $\beta = .276$, $p = .010$. However, number of siblings did not contribute to the prediction of WCST-TC score, $\beta = -.172$, $p = .103$. The regression analysis for perseverative errors score of the WCST was insignificant ($F = 3.39$, $p = .069$). When the number of siblings variable was entered into the equation, the F value decreased ($F = 2.59$, $p = .080$). Conceptual level responses score of the WCST was predicted by mothers' education, $\beta = .339$, $p = .001$. When the number of siblings was entered into the equation, mothers' education still predicted the score, $\beta = .284$, $p = .008$, but number of siblings did not, $\beta = -.190$, $p = .071$. Similarly, mother's education predicted categories completed score of the WCST, $\beta = .342$, $p = .001$ in the first equation. In the second one, it still predicted the score, $\beta = .301$, $p = .005$, while number of siblings did not, $\beta = -.140$, $p = .186$.

Digit Span Backward score was predicted by mothers' education, $\beta = .388$, $p = .000$. When the number of siblings was entered into the equation, mothers' education still predicted the score, $\beta = .360$, $p = .001$, but number of siblings did not, $\beta = -.104$, $p = .313$. The pattern was similar in the prediction of Finger Windows score. Mother's education predicted the score, $\beta = .475$, $p = .000$. In the second equation, mothers' education did predict, $\beta = .446$, $p = .000$, while number of siblings did not, $\beta = -.106$, $p = .284$. Finally, the CogAT®-NB score was predicted by mothers' education, $\beta = .539$, $p = .000$. While two independent variables were in the equation, mothers' education still predicted the score, $\beta = .500$, $p = .000$, while number of siblings did not, $\beta = -.142$, $p = .130$.

Overall, the regression analyses demonstrated that mothers' education and number of siblings together accounted for 11% of the variance of the WCST-TC score, 13% of the variance of the WCST-CLR score, 12% of the variance of the WCST-CC score, 14% of the variance of the DSB, 22% of the variance of the FW, and 29% of the variance of the CogAT®-NB scores. While mothers' education was a significant predictor for these measures, number of siblings was not. Although mother's education was found to have a significant effect on perseverative errors score of the WCST as a result of MANOVA, the regression analysis revealed that mother's education did not significantly predicted this score.

Table 8

Hierarchical Regression Analyses for the Scores

Dependent Variable	*Step*	ΔR^2	*F-change*	*p*	*β*	*p*
	1	.094	10.16	.002		
	IV1:mom's educ				.323	.002
WCST-TC score	2	.112	2.71	.002		
	IV1:mom's educ				.276	.010
	IV2: no of sib				-.172	.103
	1	.026	3.39	.069		
	IV1:mom's educ				-.194	.069
WCST-PE score	2	.035	2.59	.080		
	IV1:mom's educ				-.151	.170
	IV2: no of sib				.146	187
	1	.105	11.30	.001		
	IV1:mom's educ				.339	.001
WCST-CLR score	2	.128	7.47	.001		
	IV1:mom's educ				.284	.008
	IV2: no of sib				-.190	.071
	1	.107	11.51	.001		
	IV1:mom's educ				.342	.001
WCST-CC score	2	.115	6.69	.002		
	IV1:mom's educ				.301	.005
	IV2: no of sib				-.140	.186
	1	.141	15.43	.000		
	IV1:mom's educ				.388	.000
DSB score	2	.141	1.03	.001		
	IV1:mom's educ				.360	.001
	IV2: no of sib				-.104	.313
	1	.217	25.40	.000		
	IV1:mom's educ				.475	.000
FW Score	2	.219	1.16	.000		
	IV1:mom's educ				.446	.000
	IV2: no of sib				-.106	.284
	1	.282	35.55	.000		
	IV1:mom's educ				.539	.000
CogAT - NB Score	2	.293	2.33	.000		
	IV1:mom's educ				.500	.000
	IV2: no of sib				-.142	.130

Note. IV1: Mothers' education (in years). IV2: Number of siblings. WCST: Wisconsin Card Sorting Test, TC: Total correct responses, PE: Perseverative errors, CLR: Conceptual level responses, CC: Categories completed, DSB: Digit Span Backward. FW: Finger Windows, CogAT®-NB: The nonverbal battery of the CogAT®.

Lastly, gender and age-related differences on the scores were investigated by independent sample t test. The findings showed no significant age differences for any of the WCST, the DSB, the FW and the CogAT®-NB scores between 6- and 7-year-old children. Regarding gender, no differences were observed between boys and girls except Digit Span Backward test, $t\ (87) = 2.22$, $p < .05$; in which girls (M = 3.3, SD = 1.56) performed better than boys (M = 2.56, SD = 1.57). It was also questioned that whether there is an age difference between boys and girls. Girls (M = 82.25, SD = 3.16 in months) did not differ from boys (M = 82.35, SD = 4.38 in months) in terms of age, $t\ (87) = -.130$, $p = .89$. The means and standard deviations for the scores according to gender are presented in Table 9.

Table 9

Boys' and Girls' Mean Scores and Standard Deviations

Test scores	Gender	N	M	SD
WCST- TA	girls	44	126.59	6.21
	boys	45	127.22	3.62
WCST-TC	girls	44	54.89	18.32
	boys	45	58.84	18.29
WCST-TC	girls	44	71.7	20.95
	boys	45	68.38	19.46
WCST-PR	girls	44	34.09	19.47
	boys	45	33.84	18.05
WCST-PE	girls	44	29.7	14.96
	boys	45	31.67	16.15
WCST-NE	girls	44	41.95	19.19
	boys	45	38.29	19.08
WCST-CLR	girls	44	35.41	23.38
	boys	45	39.56	23.48
WCST-CC	girls	44	2.07	1.93
	boys	45	1.98	1.82
WCST-T1stCat	girls	44	60.75	48.28
	boys	45	61.98	44.9
WCST-FMS	girls	44	0.91	1.31
	boys	45	1.4	1.32
DSB	girls	44	3.30	1.56
	boys	45	2.56	1.57
FW	girls	44	9.3	3.49
	boys	45	10	4.14
COGAT®NB	girls	44	23.70	7.32
	boys	45	23.02	7.87

Note. WCST: Wisconsin Card Sorting Test. TA: Trials administered, TC: Total correct responses, TE: Total errors, PR: Perseverative responses, PE: Perseverative errors, NE: Nonperseverative errors. CLR: Conceptual level responses, CC: Categories completed, TC1st: Trials to complete the first category, FMS: Failure to maintain set, LL: Learning to learn, DSB: Digit Span Backward, FW: Finger Windows, CogAT®-NB: The nonverbal battery of the CogAT®

CHAPTER IV: CONCLUSION

The present study focused on four issues, (a) the relationship between executive functioning and working memory, (b) the relationship between verbal and visuospatial working memory capacities, (c) the relationship between working memory and general fluid intelligence, and (d) the effects of certain family characteristics as well as gender and age-related differences on children's EF performances.

The Relationship between Executive Functions and Working Memory

The present study revealed that verbal and visuospatial working memory tasks (DSB and FW, respectively) are significantly correlated with certain WCST scores, which seems to be compatible with the expectation that some executive processes operating in the WCST require the use of working memory. According to Dunbar and Sussman (1995; cited in Cinan & Öktem Tanör, 2002), working memory should be utilized in the WCST during the process of maintaining the sorting criterion by keeping in mind feedback of correct and incorrect responses from previous trials. This ability provides completing more categories, and hence more correct responses on the WCST. Thus, from this point of view, it is not surprising that the most robust correlations of the WM tasks were found with the 'number of categories completed' score of the WCST.

Miyake et al. (2000) pointed out that the unity among the three types of executive functions (shifting, updating and inhibition) can be presumably explained by that they all require working memory capacity. According to Bull and Scerif

(2001), on the other hand, inhibitory control is the underlying mechanism of executive functions. However, as Pennington et al. (1996) state, inhibition might be a part of working memory, rather than being an independent system since maintaining task-relevant stimuli for a certain amount of time requires inhibiting task-irrelevant stimuli at the same time.

In light of the findings mentioned above, the intercorrelations among the certain scores of the WCST, Digit Span Backward and Finger Windows in this study can be explained by the fact that all these tasks require working memory capacity during the process of maintenance of task-relevant information for a certain amount of time. The task-relevant information is 'the sorting rule' in the WCST, 'digits to be recalled in the reverse order' in the DSB, and finally, 'the spatial sequence of the windows' in the FW. The task-irrelevant or interfering information to be inhibited, on the other hand, might be the urge to respond according to previous successful sorting rule on the WCST, to count digits in a forward order rather than backward on the DSB, and to put finger into the selected windows without waiting for the sequence to be completed on the FW. Overall, it seems that the tasks used in this study require both working memory and inhibition capacities. From this perspective, the nature of the tasks used in this study seems to fit the interactive model of executive functions proposed by Roberts and Pennington (1996). This model asserts that both working memory and inhibitory control processes are necessary for intact executive functions. On the other hand, this study does not provide a definite conclusion about whether working memory and inhibition are independent capacities or not, which is an issue beyond the focus of the study.

It is necessary to note the specificity of the WCST as well as its commonality with other executive tasks. The findings of the present study demonstrated that perseveration scores of the WCST (perseverative responses and perseverative erros) did not reveal significant correlations with the DSB, the FW and the CogAT®-NB scores. Thus, it can be claimed that while working memory capacity might be a shared mechanism between the WCST, the DSB and the FW scores, the tendency to perseverate might be tapped specifically by the WCST, which reflects the unique characteristics of the test.

The Relationship between Verbal and Visuospatial Working Memory Tasks

In the present study, the correlation between verbal and visuospatial WMC tasks, that are Digit Span Backward and Finger Windows, respectively was found to be low (*r* = .33). However, one must be very cautious while interpreting this low correlation between the tasks as reflections of the nature of working memory since each construct was assessed by a single task in the current study.

Kane et al. (2004) argue that multiple measures of verbal and visuospatial WM span tasks should be used to explore the nature of working memory, and they state that

> A … broader interpretive problem with this literature is that all the studies that have reported strong dissociations between verbal and spatial WMC have used a single task to measure each construct of interest. Because all cognitive tasks reflect multiple processes, we cannot know whether the observed dissociations in these studies reflect the domain specificity of the WMC construct, or instead, the domain specificity of non-WMC related processes that also contributed to scores (i.e., task-specific sources of variance) (p. 192).

Therefore, the low correlation between the DSB and the FW scores in the current study might stem from the tasks themselves rather than a reflection of the dissociation between verbal and visuospatial working memory. A glance at the WM tasks used in previous studies revealed that the nature of these tasks, especially those designed to measure visuospatial WMC show a great deal of variety, which result in inconsistent results regarding the correlation between verbal and visospatial WM capacities. It can be argued that Finger Windows, in which the child is asked to repeat spatial sequences that the experimenter makes on a card with round windows, may not require processing component of WM sufficiently as compared to dual tasks used to measure WMC in other studies (Kane et al., 2004). For example, one of the widely known spatial WM span tasks is “rotation span” which was developed by Shah and Miyake (1996). In this task, participants are presented with capital letters or their mirror images in different rotations on a computer screen, and asked to determine whether the presented letter is normal or mirror-imaged as quickly as possible (processing task). Immediately after this, the experimenter presents short and long arrows radiating out from the center of the screen. After the display is completed, participants are asked to draw each arrow with its accurate rotation (storage task). When compared with such complex WM tasks, Finger Windows can be considered as a STM, rather than a WM task.

On the other hand, the studies mentioned above have been conducted with young adults rather than children (Shah and Miyake, 1996; Kane et al., 2004). . Engle et al. (1999) stated “tasks that are WM tasks for some people (e.g., children) might be primarily STM tasks (e.g., adults) for others, because of differential reliance on the central executive” (p. 327). Consistent with this statement, literature demonstrates that more simplified tasks are used to assess visuospatial WMC of young children. For example, Gathercole and Pickering (2000) assessed 6- to 7-year-old children’s visuospatial WMC by asking them to recall the locations of filled boxes within matrices or the correct path to go out from mazes. They found that two out of three visuospatial tasks they applied were significantly correlated with Digit Span Backward (.28 and .30). Thus, the complex span tasks proposed by Shah and

Miyake (1996) might be very difficult and hence, developmentally inappropriate for child populations. Pickering (2001) suggested that Corsi Blocks task is a typical measure of visuospatial sketchpad component in young children. Accordingly, the task is defined as

> involving nine blocks are attached to a board in a nonsymmetrical arrangement. The experimenter taps a selection of the blocks in a pre-spesified sequence (usually at the rate of one block per second) and the participant is asked to repeat the sequence. Difficulty level is manipulated by altering the number of blocks included in the sequence… (p.424)

It seems that the Corsi Blocks, which is mentioned by Pickering (2001) as a good measure of visuospatial WMC is very similar to Finger Windows. Therefore, it can be concluded that visuospatial WM tasks in previous studies conducted in child populations appear to support the fact that Finger Windows is a convenient instrument to assess visuospatial WMC of children in the present study.

Even if the FW is considered as a spatial STM task because it lacks the processing requirement of a standard WM dual-task, it has been claimed that spatial STM tasks actually tap executive control processes as well, while verbal STM tasks do not (Kane et al., 2004). In other words, spatial STM tasks might require not only storage, but also processing component of WM. Parallel to this, Burton et al. (1999) examined the validity of the WRAML by SEM and they found that Finger Windows is loaded on attention in addition to visuospatial/nonverbal factors. Therefore, there has been evidence that FW requires not only storage of spatial sequences, but also the use of attention during the task. From this point of view, the correlation between DSB and FW might be still explained by the assumption that they both require effortful and controlled attention, which is managed by the central executive.

Another point that has to be taken into consideration is that these findings are restricted to 6- to 7-year-old children, whose cognitive systems are in a developmental process. Therefore, future studies have to assess the nature of WMC in children by involving different age groups and using multiple instruments to measure each construct in order to draw robust conclusions regarding the nature of working memory.

The Relationship between Working Memory and General Fluid Intelligence

Another focus of interest in the current study was to investigate the relationship between working memory capacity and general fluid intelligence. There is a growing body of research concerning that working memory capacity (WMC) is closely related to general intelligence (*g*) and more specifically, to fluid intelligence (*gf*) (e.g., Engle et al., 1999; Oberauer et al., 2000). Since different tasks and statistical methods have been used to measure WM and *gf* constructs, the correlations between these two constructs seem inconsistent (Yuan et al., 2006). Thus, there has been an ongoing controversy among researchers regarding whether these constructs reflect the same cognitive capacity or not. Some of them have asserted that working memory and fluid intelligence are identical (e.g., Kyllonen & Christal, 1990; cited in Engle et al., 1999), others have argued that they are related but different constructs (e.g., Ackerman et al., 2005; Kane et al., 2004).

A glance at previous studies that focused on this issue reveals that the correlations between WM and *gf* tasks range from .48 to .85. Engle et al. (1999) applied a set of WM, STM and reasoning tasks to college students and the results of structural equation modeling demonstrated a correlation of .59 between WM and *gf*. The estimates of correlation (.64 and .52) between WM and *gf* reported by Kane et al. (2004) were very close to that in the study of Engle and his colleagues (1999). Kane et al. (2004) also state that

> …although WMC is strongly related to *gf*, and may be among the critical sources of general fluid ability, it is probably unwise to claim WMC to be the cognitive mechanism of *gf*. If it were, and WMC and *gf* actually reflected a single construct, then one would expect correlations between WMC and *gf* factors to be closer to the .85-.95 range rather than in the .55-.65 range. Moreover, other investigators have found that WMC and *gf* are differentially related to other constructs, which should not occur if WMC equals *gf*… (p. 210).

In the current study, the nonverbal battery of the CogAT® (CogAT®-NB) was used to measure fluid intelligence. The results demonstrated that CogAT®-NB is correlated with Digit Span Backward and Finger Windows at a moderate level. Thus, the findings of the current study seem to be compatible with the view that working memory (DSB and FW) and fluid intelligence (CogAT®-NB) instruments measure related but distinct constructs.

Engle et al. (1999) pointed out that after the variance common to STM and WM are removed, the residual of WM still showed a significant correlation of .49 with *gf* construct. They argued that the relationship between WM and *gf* is driven by controlled attention or in other words, controlled processing. Accordingly, controlled attention is required for active maintenance of task relevant information in working memory as well as for blocking distracting task-irrelevant stimuli. This domain-free, attentional construct of working memory is considered as the primary contributor to intellectual abilities involving fluid intelligence (Kane et al., 2004). In light of Engle and his colleagues' (1999) claim, it can be asserted that the correlation of the DSB and the FW with the CogAT®-NB might be explained by that they all require the capacity of controlled or executive attention. On the other hand, Oberauer et al. (2008) proposed that the capacity of relational integration accounts for the relationship between WMC and *gf* constructs. In their study, while relational integration was found to be correlated with intelligence, the other two components of WM, which are 'storage and processing' and 'supervision' were not. Since supervision tasks were mentioned to be typical measures of central attention, Oberauer et al. (2008) questioned the "controlled attention" view proposed by Engle and his colleagues (1999) by arguing that "... relational integration requires the control of attention such that the elements to be integrated are attended to simultaneously" (p. 9). Oberauer et al. (2008) claimed that controlled attention is a requirement for relational integration, which links WMC to fluid intelligence. However, this theoretical account does not seem to fit the current findings, because the WM tasks in the current study (DSB and FW) do not require the ability to build new representations among different elements (relational integration) as compared to the tasks in the study of Oberauer et al.(2008), which require finding squares between randomly placed dots on the screen, or noticing the three words, which are rhymed with each other in a row, a column or a diagonal line in a 3 x 3 grid. In this study, rather, the necessary capacity for achieving on the DSB and the FW is to keep in mind the task-relevant information for a certain amount of time by concentrating on it, which reflects much more "effortful or controlled attention".

The current results also seem to be consistent with previous findings relating intelligence to executive function measures. In the literature, there are several studies focusing particularly on the correlations between the WCST and the WISC-R in children (Arffa et al., 1998, Ardila et al., 2000). It was evidenced that the WISC-R full-scale IQ score is negatively correlated with perseverative, nonperseverative, total errors and trials to complete the first category scores of the WCST in above average and superior children (Arffa et al., 1998). Since a whole battery of intelligence like the WISC-R was not used in this study, it is impossible to make a claim regarding the relation between general intelligence and executive functions. Yet, the present study makes crucial contribution by providing data on the relationship between children's EF performances and their fluid intelligence scores. Accordingly, six scores of the WCST were found to be significantly correlated with the CogAT®-NB score: total correct responses, total errors, nonperseverative errors, conceptual level responses, number of categories completed, and trials to complete the first category. Greve et al.(2005) revealed three cognitive processes underlying the WCST, which are the ability to shift set (involving 'perseveration responses' and 'perseveration errors' scores), response maintenance ('failure to maintain set' score), and problem solving/hypothesis testing (the rest of the WCST scores). Taken the factorial structure of the WCST into consideration, it is clear that the WCST scores that were correlated with the CogAT®-NB score in fact reflect the problem solving/hypothesis-testing factor of the WCST. Thus, the correlations between these WCST scores and the CogAT®-NB performance can be explained by the assumption that both of these tasks require general problem solving or hypothesis testing ability. In other words, children have to produce hypotheses about the general rule of the task on both the WCST and the CogAT®-NB. As different from the CogAT®-NB, immediate feedback as correct or incorrect is given for each response on the WCST. The child has to understand whether he has to proceed with the same hypothesis or shift to a new one with keeping in mind the feedbacks. Thus, it can be concluded that while hypothesis testing is necessary for both tests, the ability to shift the mental set might be uniquely required by the WCST.

The Effects of Family Characteristics on EF Performance

With respect to family characteristics, the current study focused on mother's education and number of siblings. Literature provides considerable evidence that parental education is associated with cognitive abilities, and specifically executive functions (e.g., Mercy & Steelman, 1982; Ardila et al., 2005; Klenberg et al., 2001). For example, Ardila et al. (2005) explained the positive relationship between parent's education level and children's EF performances by stating that parents with high education create a "more intellectually stimulating environment" (p. 557) for their children than those with middle or low education.

In the current study, mothers' education was used as the representative of parental education due to its high correlation with fathers' education. Ardila et al. (2005) mentioned that the mean difference in the education level between fathers and mothers was less than one year of education in their study, and they asserted that the difference in children's EF performances might be explained by "a home effect" rather than "a mother effect" or "a father effect". In the current study, consistent with the argument of Ardila et al. (2005), the mean difference between mothers' education ($M = 11.36$, $SD = 3.68$ in years) and fathers' education ($M = 11.82$, $SD = 3.39$ in years) was found to be less than one year. Therefore, the current findings might be considered as an indicator of intellectual atmosphere of the home rather than only mother's education.

The current findings revealed that mothers' education significantly influenced certain WCST scores as well as children's working memory and nonverbal reasoning performances. In general, children's performances on the measures increased as their mothers' education levels increased. This pattern can be explained by a similar explanation to Ardila et al. (2005) made that mothers with high education create an intellectually stimulating environment that facilitates learning and problem solving through high-quality interaction with their children.

Besides, it is important to note that mothers' education was found to be associated with perseverative errors children made on the WCST in this study. Children were found to make less perseverative errors as their mothers' education levels increased. This finding is consistent with previous evidence, which showed that mothers' education is an important predictor for perseveration in children (Yeniçeri & Atalay, 2008). Perseveration is defined as the inability to shift well-learned strategy to solve the problem. As a result of their high education, these mothers might be better equipped to deal with complex tasks, that may be manifested in their cognitive flexibility, which is transmitted to their children's problem solving skills. Therefore, in the future studies, how mothers' education influences children's complex cognitive processes should be further explored by obtaining information about how mothers communicate with their children, how much time they spend with them, what kinds of activities they do together.

With respect to number of siblings, the current findings revealed that singletons completed more categories and more total correct responses, and they made fewer total, nonperseverative errors and trials to complete the first category on the WCST than children with siblings did. This pattern can be explained by that siblings might limit parental resources, which has a negative effect on children's cognitive abilities. Consistent with this explanation, Mercy and Steelman (1982) found that both number of younger siblings and number of older siblings are negatively correlated with both verbal and nonverbal intelligence. An interesting finding of the current study is that children with two or more siblings performed better than those with one sibling did on the WCST although the mean differences between their performances were very small. It seems that research focusing on the relationship between number of siblings and executive functioning is sparse. However, Ruffman, Perner, Naito, Parkin, and Clements (1998) have shown that having older siblings, but not younger, is advantageous in terms of theory of mind; which has been evidenced to be much related to executive functioning (Carlson, Moses, & Breton, 2002). Regarding intelligence, Mercy and Steelman (1982) stated that

> …younger children probably diminish the quality of the intellectual climate greater than older siblings….although older siblings limit parental attention and other resources, they should also stimulate companionship than younger siblings (p.539).

Although this study did not include information regarding birth order, it seems likely that some children with two and more siblings have at least one older sibling. Considering literature on the theory of mind, this might be the reason why children with two or more siblings had better performance than those with one sibling on the WCST. However, this assumption needs to be explored further in future studies with taking information about birth order of participants.

As opposed to the WCST, number of siblings did not have a significant effect on the DSB, the FW and the CogAT®-NB scores. However, the mean scores of the sibling groups demonstrated that as the number of sibling increased, children's performances on these measures decreased, which appears to be consistent with previous findings (Mercy & Steelman, 1982). Thus, it can be concluded that the more limited parental resources, the lower the general cognitive functioning of children.

Taken together, the regression analyses revealed that mothers' education and number of siblings together accounted for 11% of the variance of the total correct responses, 13% of the variance of conceptual level responses, and 12% of the variance of the categories completed scores of the WCST. These scores can be considered to reflect general conceptual thinking capacity (hypothesis testing/problem solving factor) according to factorial structure of the WCST (Greve et al., 2005). In contrast, mothers' education did not predict the variance of perseverative errors score of the WCST although MANOVA results demonstrated that it had a significant effect on this score. Thus, it can be asserted that while general conceptual thinking capacity might be open to environmental effects such as parental education, perseveration might be relatively independent from these kinds of effects. This finding seems to be inconsistent with previous studies, which showed that mothers' education is a significant predictor for perseveration in children (Yeniçeri & Atalay, 2008). This issue should be explored further in larger samples.

The current findings also demonstrated that mother's education and number of siblings together explained 14% of the variance of the DSB, 22% of the variance of the FW, and 29% of the variance of the CogAT®-NB scores. While mothers' education was found to be a significant predictor for these measures, number of siblings was not. It is surprising that these family characteristics accounted for the largest variance in the nonverbal battery of the CogAT®, a measure of fluid intelligence, which is assumed to be relatively independent from cultural and school-based learning. On the other hand, although *gf* tasks assess the ability to solve in novel and unfamiliar situations, the familiarity with nonverbal materials such as puzzles, geometric shapes and other kinds of cognitively stimulating toys might provide the child an advantage on nonverbal reasoning tasks. From this point of view, it can be considered that mothers with high education might provide sophisticated activities and experience for their children, which might facilitate children's problem solving on nonverbal tasks.

In addition, literature provides evidence that highly educated mothers read more and make more conversations with their children (Shonkoff & Phillips 2000, cited in Bradley & Corwyn, 2002). Since the DSB is considered to be related with children's verbal abilities, it can be assumed to be much more open to the effects of parental education than the FW. However, the current findings showed that the variance predicted by the family characteristics is larger in the visuospatial WM than that in the verbal WM tasks. Overall, the findings revealed the importance of mothers' education in children's diverse cognitive processes, which points to the necessity of designing educational programs for mothers with relatively low education.

Literature provides some evidence that mother's occupational status is an associated variable with children's cognitive abilities although different researchers put forward different explanations for the effects of this variable on children's cognitive performances. In this study, this variable and its relation with mothers' education and number of siblings could not be explored due to small sample size of the study. Future studies should focus on whether children of working and those of nonworking mothers show differences on EF tests and other cognitive ability tasks.

The Effects of Child Characteristics on EF Performance

Gender Differences

Consistent with the previous findings regarding the WCST, the current study does not reveal sex difference on the WCST scores. Concerning working memory capacity, it was found that girls performed superior to boys on Digit Span Backward, but not on Finger Windows. The finding about the DSB seems to be consistent with Lynn and Irwing (2008), whose review demonstrated that there is a female superiority on the Wechsler Digit Span Test in children and adolescents. Yet, it is important to note that the Wechsler Digit Span subtest includes both forward and backward digit span. In this study, however, only Digit Span Backward was used due to time limitations during the data collection process. Further, Lynn and Irwing (2008) argued that this female advantage in digit span cannot be interpreted as that girls have an advantage in working memory capacity because digit span measures immediate memory capacity rather than WMC. As opposed to Lynn and Irwing's (2008) criticisms, there is substantial evidence demonstrating that particularly backward digit span is a good measure of WMC (Oberauer et al., 2000). In sum, although the current study reveals a female advantage in Backward Digit Span, which was used as a verbal WMC task, this finding should be explored further by applying multiple WM tasks in future studies.

In addition, there seems to be an inconsistency with respect to gender differences in visuospatial cognitive abilities due to the variability of the tests. Halpern (1992), on the other hand, indicated that males performed better than females in visual-spatial tests, which require maintaining and manipulating mental representations such as mental rotation. In the current study, the mean scores for the

Finger Windows show that boys' performance (M = 10, SD = 4.1) is higher than that of girls (M = 9.3, SD = 3.5). However, since the mean difference is not significant, it cannot be mentioned about a male advantage on Finger Windows. Future studies should use multiple visuospatial WMC tasks in larger samples for more robust conclusions about gender differences in verbal and visuospatial WMC.

Concerning gender differences in nonverbal reasoning ability, Irwing and Lynn (2005) found a male advantage on the Raven's Progressive Matrices in university students. On the contrary, Strand et al. (2006) revealed that girls performed better than boys did in nonverbal ability measured by the CAT3 among children. This variability in findings might stem from that different tests were used in different samples. In the current study, on the other hand, boys (M = 22.9, SD = 7.8) and girls (M = 23.6, SD = 7.3) did not differ from each other in terms of their performance on the nonverbal battery of the CogAT®. This seems to be parallel to Alp and Diri's study (2003), which demonstrated no sex difference in overall composite scores of the CogAT® in a Turkish sample.

Overall, the current findings did provide evidence for gender differences in the DSB, but not in the WCST, the FW and the CogAT®-NB performances. Therefore, it can be concluded that the current study supports Halpern's (1992) statement that "Males and females are overwhelmingly alike in their cognitive abilities."(p.96). "…and similarities between the sexes are greater than the differences" (p.97).

Age Differences

The findings revealed that 6-year-old children did not differ from 7-year-olds on EF, WM and FI performances, which might stem from the fact that all participants were first graders. Therefore, it can not be mentioned about educational differences while comparing 6-year-old children's performances with that of 7-year-olds. Second, the age range of the sample was from 6.2 years to 7.7 years, so 7-year-old group actually does not represent children older than 7.7 years. Besides, 6-year-old children had a mean age of 6.7 years while the mean age of 7-year-olds was 7.2 years, which indicates that the age difference between these groups was only 5 months. Third, 6-year-old children make up 58% of the total sample (N = 52), 7-year-old children is just 42% (N = 37), indicating an unequal distribution of the sample between the groups. To sum up, the findings concerning age differences in this study should be treated with caution due to these kinds of limitations.

Nonetheless, this study has contributed to the WCST norms for 8-to 11-year-old Turkish children presented by Yeniceri and Atalay (2008) by providing normative data from 6- to 7-year-old children. Although the WCST is accepted as a complex and multidimensional EF test, it appears that children at a mean age of 6.10 can achieve the test to a certain level. However, when the results were compared to previously reported data, it was found that the mean scores of the WCST in this study are much lower than those reported by Rosselli and Ardila (1993) and those reported by Shu et al. (2000) for corresponding ages. Future normative studies should involve larger sample sizes to investigate this finding.

Limitations

There are some shortcomings of this study. First of all, the sample size was restricted to eighty-nine children, which limits the generalization of the results. Larger sample size will also allow for examining factorial structure of the WCST for this age group, which will contribute to establish construct validity. Second, multiple instruments should be used to measure each construct of interest since it is impossible to know whether a single task reflects all aspects of a construct. This study should be replicated with multiple measures assessing each construct of interest in larger samples. Third, the information about the birth order of the participants should have been obtained in order to explore the effect of number of younger and older siblings on EF performances. Finally, more information about other family and parenting variables such as mother's occupational status should be involved in addition to mothers' education and number of siblings, and more advanced statistical methods should be used to explore direct and indirect paths from familial variables to children's EF performances in future studies.

APPENDICES

APPENDIX A

Informed Consent Form

BİLGİLENDİRİLMİŞ OLUR FORMU

Sayın Veli,

Boğaziçi Üniversitesi Psikoloji Bölümü Yüksek Lisans 2. sınıf öğrencisi Nihal Yeniad tarafından hazırlanmakta olan "*Wisconsin Kart Eşleme Testi'nde 6-7 Yaş Grubundaki Çocukların Ortalama Başarılarının Belirlenmesi*" konulu tez araştırmasına bu yaşlardaki ilköğretim öğrencilerinin katılımı beklenmektedir. Söz konusu test bir kavramsal irdeleme ve dikkat ölçeğidir. Bu teste ilave olarak, dikkat ve hafızayı farklı açılardan ölçmek amacıyla *'Sayı Dizisi'* ve '*Finger Windows'* testleri de uygulanacaktır.

Okul müdürlüğünüzün uygun bulduğu saatler içerisinde yürütülecek olan çalışmada test öğrencilere teker teker uygulanacaktır. Testin tamamlanması her çocukla yaklaşık 40 dakika sürmektedir. Söz konusu ölçeklerin çocuklar üzerinde olumlu ya da olumsuz bir etkisi yoktur. Bu araştırma projesi Boğaziçi Üniversitesi Psikoloji Bölümü öğretim elemanlarının denetimi altında yürütülmektedir.

Çalışmaya katılacak tüm öğrencilerin kimlik bilgileri gizli tutulacaktır. Her katılımcı istediği an testi bırakma özgürlüğüne sahiptir. Araştırmaya yalnızca velisinin izni olan öğrencilerin alınacağını belirtir, çocuğunuzun katılımı için izninizi rica ederim.

Sorularınız için aşağıda belirtilen numaraları arayabilirsiniz.

Saygılarımla.

Tez Öğrencisi
Nihal Yeniad
Psikoloji Bölümü
Yüksek Lisans öğrencisi
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Proje Yürütücüsü
Dr. Nur Yeniçeri
Psikoloji Bölümü Öğretim Görevlisi
Boğaziçi Üniversitesi
Tel: (212) 5397055/3597080

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

Velinin Adı Soyadı:

İmza:

Tarih:

APPENDIX B

Demographic Information Form

DEMOGRAFİK BİLGİ FORMU

ÇOCUĞUNUZUN İSMİ____

ÇOCUĞUNUZUN DOĞUM TARİHİ (gün/ay/yıl)___________________________

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

Annenin mesleğini yazınız:____

Annenin eğitim seviyesini işaretleyiniz:

a) Lisansüstü (yükseklisans ve/veya doktora)

b) Üniversite mezunu

c) Lise mezunu

d) İlköğretim mezunu

e) Okur yazar

Babanın mesleğini yazınız:____

Babanın eğitim düzeyini işaretleyiniz:

a) Lisansüstü (yükseklisans ve/veya doktora)

b) Üniversite mezunu

c) Lise mezunu

d) İlköğretim mezunu

e) Okur yazar

Ailedeki çocuk sayısı kaçtır? _____________

Çocuğunuzun belirtmek istediğiniz bir sağlık sorunu var mı ?

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